PROJECTS ■ THEORY ■ APPLICATIONS ■ CIRCUITS ■ TECHNOLOGY

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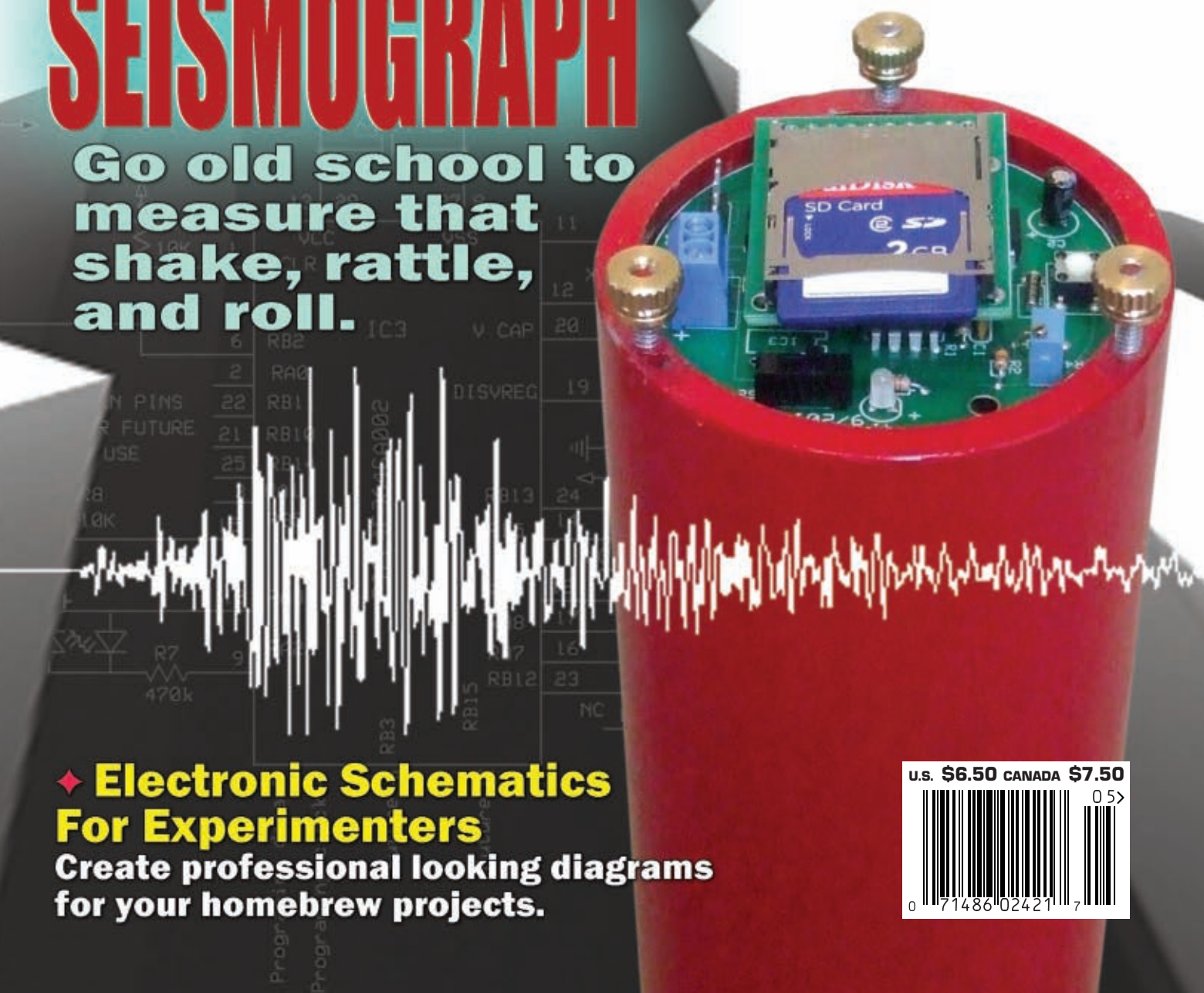

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The SB70LC Development Kit

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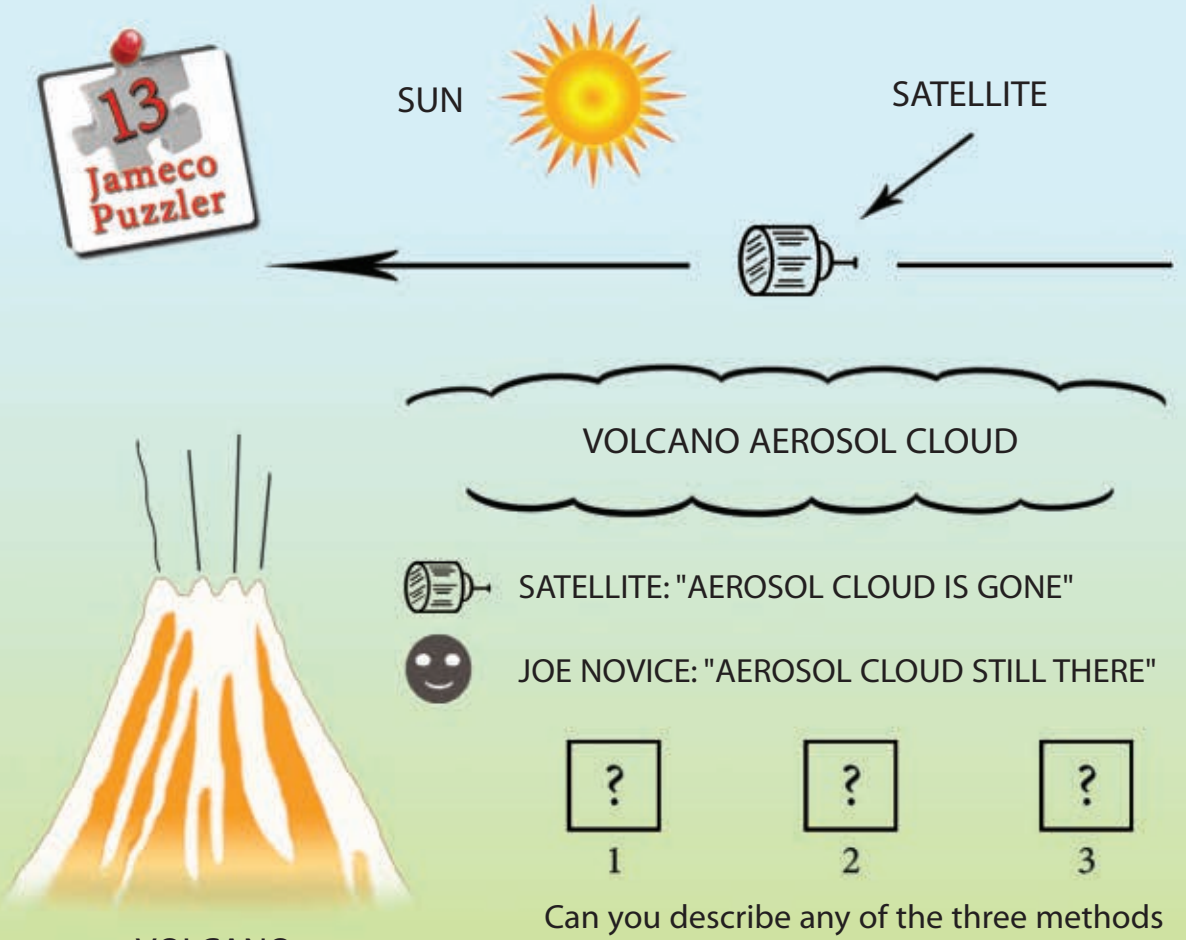

Can you describe any of the three methods Joe used to detect the aerosol?

Satellites provide global coverage of clouds, water vapor, dust, smoke and the ozone layer. The colorful images provided by the data from these satellites looks very impressive. But satellite instruments don't always stay calibrated and problems can occur when satellite orbits drift. Amateur scientist, Joe Novice learned about this when he heard a satellite scientist say that the global aerosol cloud formed by the eruption of a giant volcano had dissipated much sooner than expected. Joe suspected the satellite was simply wrong, but he was not a satellite scientist. How did he use some everyday items and several electronic components to prove he was right?

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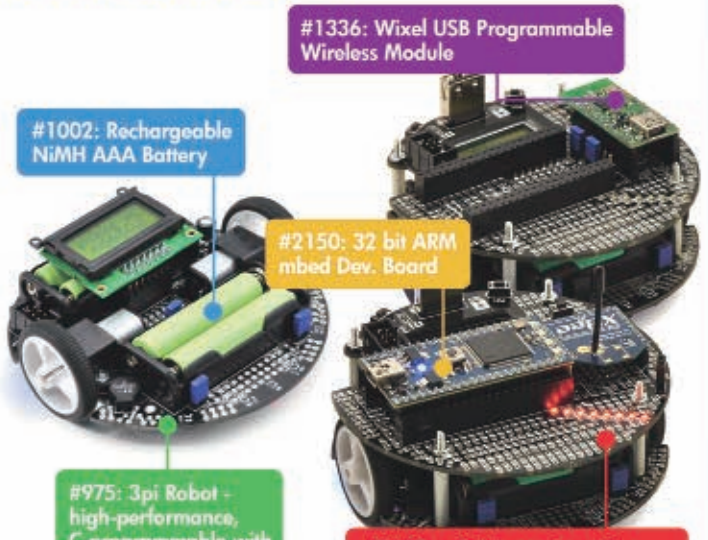
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CHR-UM6
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Hobby/RC Servo Controllers:
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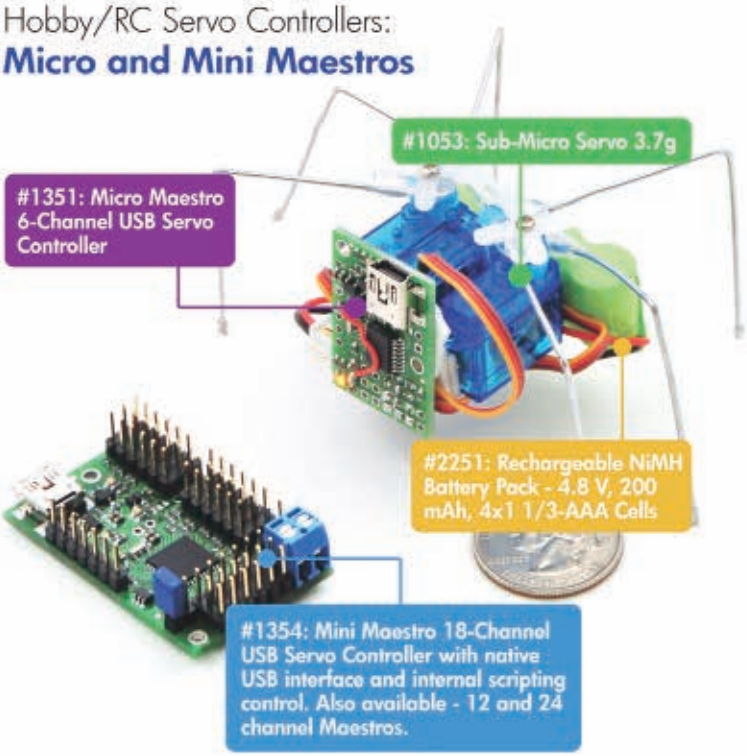
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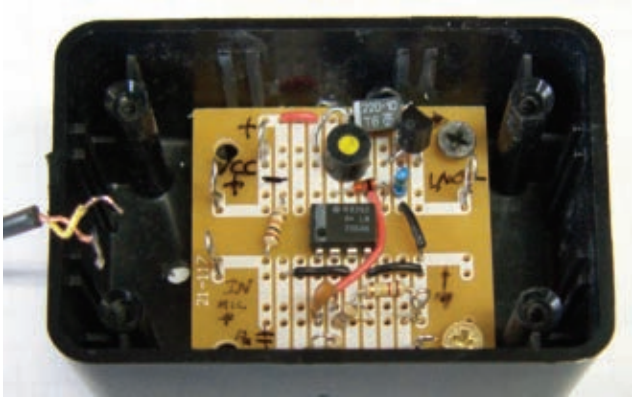


Page 40

Projects & Features

32 Build the Poor Man's Seismograph
Now that earthquakes seem to be happening almost anywhere, give yourself a head's up on any shaking, rattling, or rolling that may happen in your area.
■ By Ron Newton

40 Build a Sound-Activated Laser Parking System
If you'd like to break free from your "hanging tennis ball" method of parking, check out this approach which utilizes two ordinary low power laser pointers.
■ By Paulo Oliveira

46 Electronic Schematic Diagrams for Experimenters and Technicians
Read about some of the options you have to create your own professional looking diagrams.
■ By David Herres

FUNdamentals For Beginners
76 Build a Nose Beeper

Departments

08	DEVELOPING PERSPECTIVES	67	ELECTRO-NET
28	NEW PRODUCTS	77	CLASSIFIEDS
30	SHOWCASE	78	TECH FORUM
64	NV WEBSTORE	81	AD INDEX

Columns

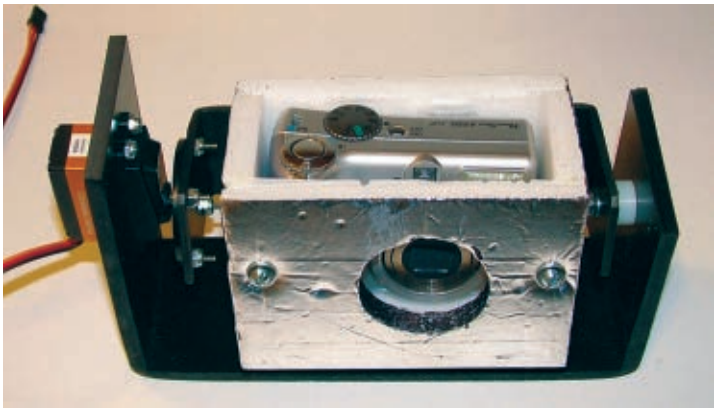
10 TechKnowledgey 2012
Events, Advances, and News
This month, read about really twisted radio, no-compromise sound from your PC, a sonic screwdriver, plus some other interesting stuff.

14 The Spin Zone
Adventures in Propeller Programming
Back to the Beginning.

24 Q & A
Reader Questions Answered Here
AC ammeters, battery internal resistance, and transformerless power supplies are discussed this time.

52 The Design Cycle
Advanced Techniques for Design Engineers
Control Gadgets With Your Smart Phone.

58 Near Space
Approaching the Final Frontier
Making One Camera Do the Work of Three.



68 Smiley's Workshop
Programming • Hardware • Projects
Chaser Light Marquee — Part 2.

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DEVELOPING PERSPECTIVES

Infant Mortality

Perhaps it's just me, but I get the feeling that components just aren't as good as they used to be. I've had a run of defective wall-wart power supplies, an IC that suddenly failed in-circuit with a puff of smoke, and potentiometers for an audio preamp project that just don't meet specifications for resistance. I suppose it's a reflection of cost-cutting measures in the electronics industry.

So-called early life or infant mortality problems are nothing new in the electronics industry, and there are numerous standards established by the military and industries to indicate the likelihood of component failure over time. My experience with component and board failures suggests that if a circuit or component functions adequately for 24 hours, it will last indefinitely if operated within design limits. For example, all bets are off if you subject a board to electrostatic discharge (ESD) or your power grid is hit by lightning.

Component and board failures can be soft (a change in value or performance) or hard (the component fails completely). Hard failures in high voltage components are often spectacular. I've had several electrolytic capacitors explode and flame out because of dry electrolyte. Low voltage components, in contrast, tend to simply smolder.

Soft failures are especially problematic in analog circuits. For example, resistor and capacitor values may change significantly over time, and op-amp performance may suddenly diminish. Such failures can be difficult to diagnose or correct in a complex analog circuit. I've only had one soft failure over the past few years on a digital circuit board — it was the linear voltage regulator chip, and not the digital electronics.

My most recent failure was that of an analog-to-digital converter (ADC) circuit. I built six identical boards for a project. As luck would have it, I had only five IC sockets for the key analog chip, and the chip that was soldered directly to the board failed. After about

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two hours, the chip made a snapping sound, followed by the telltale smell of a burned component. The chip's failure could have been due to the thermal stress of soldering or simply a defective chip. Whatever the cause, removing the chip and preparing the board for the replacement chip was time consuming.

My experience highlights two aspects of component failure. The first is you should be proactive in your designs. This includes using sockets for expensive or difficult to replace components, and ordering a few spare components when you first place your order. You don't want to be in the position of having to order a single component for 32 cents and paying $11 for shipping.

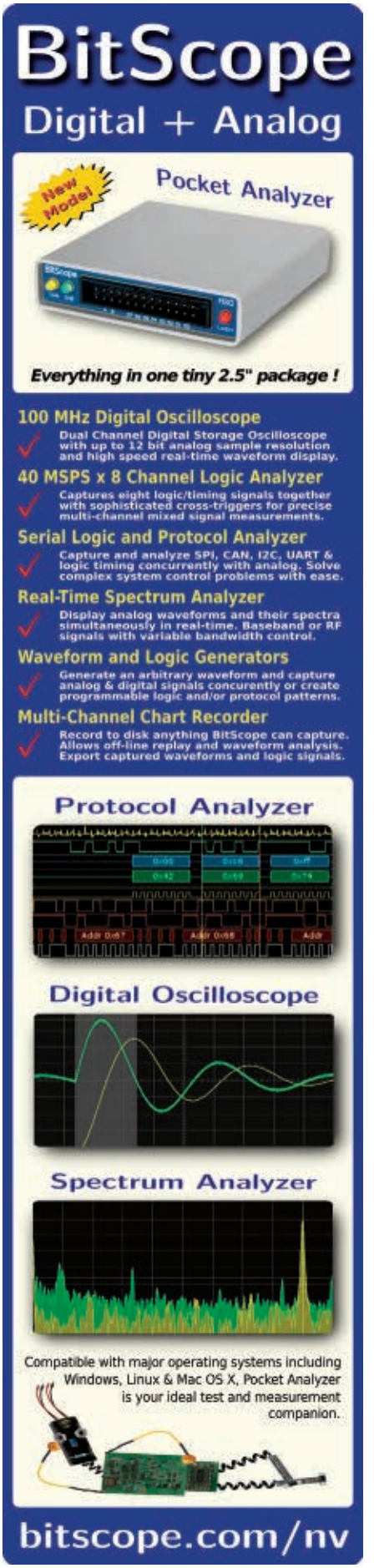
The second take-away is that you should make a habit of burning-in high value circuits. By this, I mean circuits that have to work — a garage door opener, controller for your R/C helicopter, or a device you're selling or providing as a gift. I have a burn-in area on my workbench. It's a 12 x 12 inch square of flame and heat resistant Formica laminate. I place the circuit in the center of the platform and connect a regulated, current-limited power supply to it, then let it cook for as long as I'm in the room.

Moreover, if the circuitry is rated at, say 9-12 volts, I stress it with 12.5 volts. My goal is to have the circuit fail on my workbench — before I spend time mounting the circuit in an expensive enclosure.

This brings me to something else that I've noticed lately — cost cutting in test equipment. In particular, if your new bench supply is rated at say, five amps, don't assume that the leads can handle that level of current indefinitely. After one burn-in session, I found that a component had a hard failure, resulting in a short. The power supply was unharmed, but the insulation on the wimpy leads had partially melted, exposing the copper wire. I've since replaced the power supply leads with 12 gauge, heat-resistant wire, solid banana plugs, and beefy alligator clips.

If you'd like more information on component reliability, check out military standard MIL-HDBK-217, commonly referred to as MIL-217.

NV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TECH KNOWLEDGEY 2012

EVENTS, ADVANCES, AND NEWS

■ BY JEFF ECKERT

ADVANCED TECHNOLOGY

REALLY TWISTED RADIO

For many years, allocation of the increasingly busy frequency spectrum has presented a challenge, and the introduction of mobile smartphones, digital TV, and wireless Internet has only added to the problem. However, a group of researchers from the University of Padova, Italy, and the Angstrom Laboratory, Sweden, have come up with a way to ease the congestion by manipulating radio waves so they can hold multiple channels of information in the same band. The technique — described in a recent issue of the Institute of Physics and German Physical Society's *New Journal of Physics* — involves twisting the transmissions. According to lead author Dr. Fabrizio Tamburini, "In a three-dimensional perspective, this phase twist looks like a fusilli-pasta-shaped beam. Each of these twisted beams can be independently generated, propagated, and detected, even in the very same frequency band, behaving as independent communication channels."

■ Helicoidal parabolic antenna used for the twisted radio waves.

Apparently, it is possible to twist a wave about its own axis a certain number of times — both clockwise and counterclockwise — thus enabling several different configurations. To demonstrate the principle, the researchers transmitted two twisted waves in the 2.4 GHz band from a lighthouse on San Georgio Island to a satellite dish on the Venice mainland 0.27 miles (442 m) away, where the dish was able to pick up the two separate channels. "Within reasonable economic boundaries, one can think about using five orbital angular momentum states, from -5 (counterclockwise) up to 5 (clockwise), including untwisted waves. In this instance, we can have 11 channels in one frequency band ... It is possible to use multiplexing — like in digital TV — on each of these to implement even more channels on the same states, which means one could obtain 55 channels in the same frequency band," added Tamburini. For a video explaining the concept in greater detail, see **www.youtube.com/watch?v=Z1l8_bZr5fI**. ▲

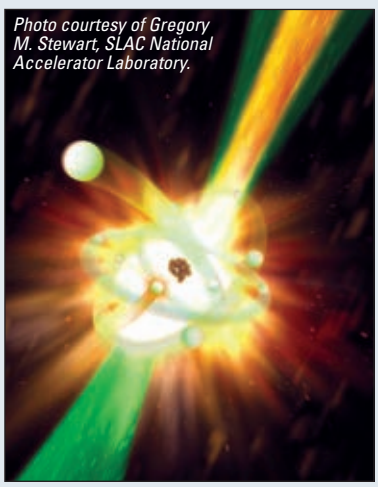


Photo courtesy of Gregory M. Stewart, SLAC National Accelerator Laboratory.

■ A powerful x-ray laser pulse comes up from the lower left corner (green) and hits a neon atom (center).

X-RAY LASER DEMONSTRATED

For many years, it has been deemed possible to produce an x-ray laser beam by removing some atom's inner electrons and inducing them to fall to lower energy levels, thus releasing a single color of light. The problem is that — until recently — no x-ray sources existed that were powerful enough to do it. Earlier this year, however, researchers at the Stanford Linear Accelerator Center (SLAC, **www.slac.stanford.edu**) aimed radiation from their $410 million Linac Coherent Light Source at some neon gas and set off an avalanche of emissions, thereby creating a new "atomic x-ray laser." To make it work, they had to use x-ray pulses — each a billion times brighter than any available before — to knock electrons out of the inner shells of the neon atoms. When the remaining atoms fell into the holes, about two percent of them responded by emitting a short-wavelength x-ray. Those, in turn, stimulated neighboring atoms to emit more x-rays, creating a domino effect and amplifying the laser light by 200 million times. It's likely to be a matter of years before the technology finds any kind of general use, but it is said to have potential applications in materials science, spectroscopy, and other areas. In the future, the team will try to create even shorter pulse, higher energy atomic x-ray lasers using oxygen, nitrogen, or sulfur gases. ▲

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

COMPUTERS AND NETWORKING

DELL ADDS TO ULTRABOOK MARKET

■ Dell's newly introduced XPS 13 Ultrabook.

Joining the ranks of PC manufacturers eager to bump the MacBook Air off its throne, Dell recently started shipping the XPS 13 — not so modestly dubbed the "best Ultrabook on the planet" by Dell's Jeff Clarke. Marketing hype notwithstanding, it has been greeted with widespread positive reviews. The 13.3 inch machine features second-generation Intel Core i5 or i7 processors, Intel HD 3000 graphics, a full-size backlit chiclet keyboard, and a high-def WLED Gorilla Glass display with everything packed into a package that starts at a hair under 3 lb (1.36 kg). The carbon fiber composite case measures 12.4 x 8.1 in (316 x 205 mm), with the thickness ranging from 0.24 to 0.71 in (6 to 18 mm). Other standard features include Intel HD 3000 video graphics, 4 GB of SDRAM, 128 and 256 GB SSD options, and Waves MaxxAudio 4. It also comes with a built-in 1.3 MP webcam with dual array digital microphones. Battery life is rated at up to 8 hr, 53 min per charge. MSRP starts at $999. ▲

■ Audioengine's 5+ powered speakers with handmade bamboo cabinets.

NO-COMPROMISE SOUND FROM YOUR PC

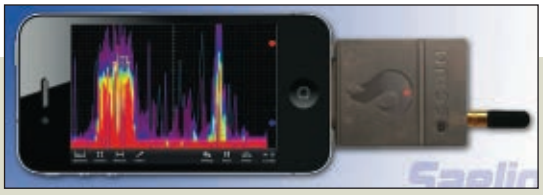
If all you want is to bypass the crappy little speakers in your PC and get something that resembles acceptable sound, you can pick up a pair of crappy bigger speakers at Walmart for around $10. Or, you can spend about ten times that much and pick up something better — like maybe the Bose Companion® system. If you insist on audiophile-quality, eardrum-bleeding stereo, however, take a look at the Audioengine (**audioengineusa.com**) 5+ Premium Powered Speakers. The 5+ is basically the same as the company's flagship A5, but it includes some customer-requested upgrades. The built-in amplifier drives up to 50W RMS per channel into five inch custom Kevlar woofers and 20 mm silk dome tweeters which are installed in hand-built cabinets. According to the company, "You won't hear any enhanced super-mega-hyper-monster boomy bass from these powered speakers. As with the original A5, the low end from the A5+ is real bass, very near to the originally recorded music." The system works with any computer, as well as all iDevices (iPod, iPhone, iPad), Airport Express + AirPlay, and any other product with mini-jack or RCA outputs. You get 50 Hz to 22 kHz (±1.5 dB) frequency response, >95 dB signal to noise, and <0.05 percent THD. You'll need to put your PC on something other than a folding card table, though, as the left speaker (which contains the amp circuitry) weighs in at 15.4 lb (7 kg). The right one tips the scale at 9.6 lb (4.4 kg). Both measure 10.75 x 7 x 7.75 in (27 x 18 x 20 cm). With a bag of cables and other accessories, the 5+ system will run you $399 (satin black or high gloss white cabinets) or $469 (solid carbonized bamboo). ▲

HIRE A KILLER FOR FREE

Most websites make it extremely simple to sign up, but it can be difficult — if not downright impossible — to cancel your account when a site has finally become unbearably annoying. (Anyone thinking Skype about now?) You may have to search through multiple obscure menu layers to find a way to dump them, and sites may retain and use your personal information even after you have left them in the digital dust. Take heart, though, because AccountKiller (**www.accountkiller.com**) is here to serve you. The site provides instructions on how to delete your account and public profile on many websites and even offers one-click removal for some of the more popular ones (Facebook, Twitter, Google, et al.). Plus, you can get an ease-of-service rating for sites before signing up and look up blacklisted sites to avoid. The service is free, but you are encouraged to make a donation. ▲

CIRCUITS AND DEVICES

TURN YOUR iPHONE INTO AN ULTRAPORTABLE TEST INSTRUMENT



■ WiPry-Combo turns your iDevice into a spectrum analyzer/power meter.

A nifty gadget from Saelig Company, Inc. (**www.saelig.com**), is the WiPry-Combo, billed as the world's first dynamic power meter and spectrum analyzer for the iPad, iPod, iPod Touch, and iPhone. Offering a touch interface that's not available with PC-based instruments, it turns any iDevice into an ultraportable test instrument. In the spectrum analyzer mode, it allows users to identify interference or open channels in the 2.4 GHz ISM band or to recognize unauthorized Wi-Fi access points. Operating from 2.400 to 2.495, it measures signals from -40 to +20 dBm with amplitude resolution of 2.0 dBm and bandwidth resolution of 1 MHz, with a band sweep time of 200 ms. In the power meter mode, it becomes a 100 MHz to 2.7 GHz RF power meter, providing a graphic display of RF power levels with a timescale adjustable between 2 s/div and 1 s/div. Signal amplitude is displayed from -45 to +20 dBm with 2.0 dBm resolution. If you want to check it out before buying, you can download a free demo package (which does not require the actual WiPry device) at Apple's AppStore, and it is available in English, French, German, Italian, and Spanish. The WiPry-Combo retails for $199.95. If you don't really care about the power meter function, you can opt for the WiPry-Spectrum version for only $99.95. ▲

■ Vizio's 58 in 3D CinemaWide display widens widescreen TV.

ANOTHER ASPECT OF TV

If it took you a while to get used to having TV sets with both the boxy old 4:3 aspect ratio and the 16:9 ratio used by HDTV, brace yourself. Like the bellies on us couch potatoes, screens are still getting wider. Vizio's (**www.vizio.com**) new 58 in 3D LED CinemaWide display is the first to employ a 21:9 ratio, resulting in a super-wide screen that addresses a yet-to-be-developed Consumer Electronics Association (CEA) standard to allow the format to be carried over current HDMI video cables. This will allow Hollywood films to fill the screen without black bars on the top and bottom, and viewers can also use smart TV applications on the left side of the screen while showing a 16:9 image to the right. The main objective is to offer viewers something that has more like the look and feel of a movie theater. "When you have a CinemaWide display in 3D in your living room and you are watching a 21:9 movie, that can be as good or better than some theater experiences," according to Vizio VP John Schindler.

Vizio's CinemaWide models display 3D content and include more than 180 Vizio Internet apps. The set lists for $3,499.99, so get out the checkbook. It does include four pairs of 3D glasses, so you won't have to fight the kids over them. The company intends to bring out 50 and 71 in models later this year. ▲

NEW SONIC SCREWDRIVER

■ Amaze your friends with your own Doctor Who sonic screwdriver.

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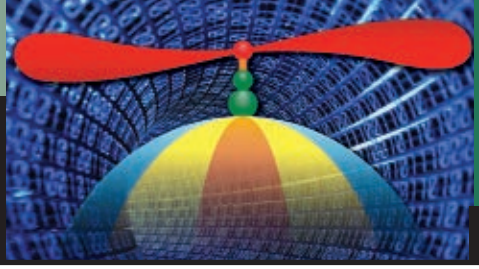


SPIN ZONE

ADVENTURES IN PROPELLER PROGRAMMING

■ BY JON WILLIAMS

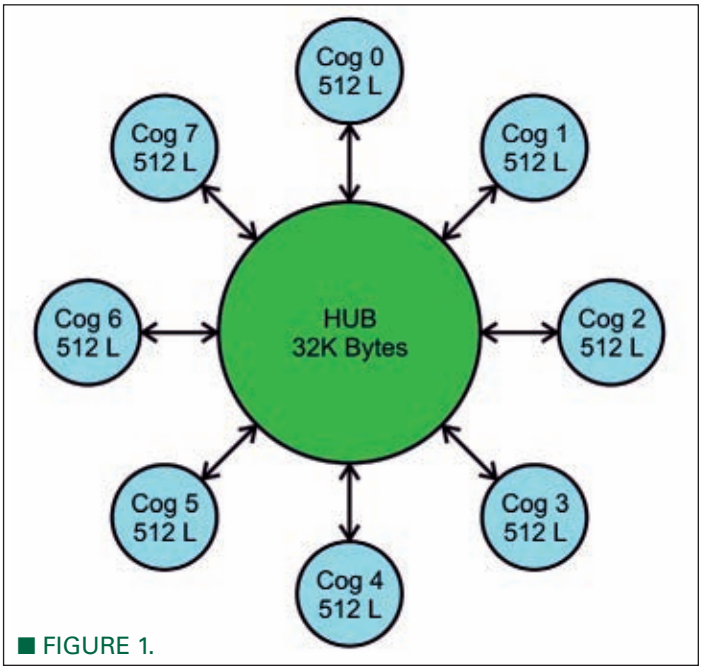
Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

BACK TO THE BEGINNING

Wow! It's hard to believe that this marks the three year anniversary of the Spin Zone column. Time really does fly when you're having fun. In that time, I have written several thousand lines of Propeller code — mostly in Spin — but a fair amount in PASM (Propeller Assembly), as well. Mind you, I certainly don't consider myself an extraordinary programmer, and Assembly is not my first choice. That said, I've become pretty comfortable with PASM and have — for the most part — been able to solve problems with it when I need to.

The Propeller is no longer the new kid on the block and it seems to me, anyway, that it is getting a surge in interest. From what I've noticed in the Propeller forum, there is a growing interest in PASM, as well. Why shouldn't there be? Assembly is the base language of any microcontroller and gives us the greatest speed. Oftentimes, this is very important. I have had those occasions where I would code a driver in Spin only to find that I really needed it to run faster. Perhaps you have, too.

Now, before we jump in (again) I need to apologize. In the course of this column, I'm going to lay out suggestions that I have not followed in the past. You will find past columns online where I have violated these suggestions. I'm sorry; I was drunk when I wrote those columns. Okay, no I wasn't, but what I was — at the time — was short-sighted. The suggestions I make here will allow our PASM efforts to work with Spin and with other languages, as well.



■ FIGURE 1.

BACK TO THE BEGINNING

Let's review the basic structure of the Propeller in terms of RAM since all code runs out of RAM. The bulk of it is located in the hub; here, we have 32K bytes and this space can be addressed as bytes, words, or longs. Each cog has its own RAM for program code and data; each cog has 512 longs. Note there is a distinction here: In the hub, we can treat RAM as bytes, words, and longs. In the cog, we only have longs. Even if we transfer a byte from the hub to a cog (using the **rdbyte** instruction), the destination variable in the PASM cog will be a long.

At boot-up, the Propeller checks its programming port to see if an IDE (Integrated Development Environment) just caused the reset in order to download a new program. If this is, in fact, the case the Propeller will accept the new program into the hub RAM and — if directed by the IDE — will copy the hub RAM to its external EEPROM so that it can be loaded on the next normal power-up/reset.

When a normal power-up or reset occurs — that is, there is no IDE wanting to do a download — the Propeller will transfer the contents of the EEPROM to the hub RAM, start a Spin interpreter in cog 0, and then launch the user program.

Here's an important point: Even if we were to create a single-cog program that runs in PASM, we still need at

least one line of Spin code to launch it. Under this condition, our PASM code would be loaded into a cog (cog 1 unless otherwise directed by using **coginit**) and then cog 0 would terminate as it's out of code to run.

Before we get into writing PASM code, let's look at that one line of Spin we need (at a minimum) to launch PASM code into a cog. In most cases, we will use **cognew**. Let's say, for example, that we keep with tradition and do a blinky LED program that will run on any simple platform (e.g., a QuickStart board that you can pick up at RadioShack or All Electronics). We might do something like this:

```
cognew(@blinker, @blinkpin)
```

The first parameter of **cognew** is the address that is the start of our Assembly program for the cog; this code will be housed in a **DAT** section in our listing. The second parameter is loaded into a special register called ***par***, and this is the key to communications between high level code and the newly launched PASM cog.

Suggestion #1: *If there is any information moved from the hub to the cog (or vice versa), then the value passed in the **par** register should be the address of a long variable, usually located in the global space of the object.*

Why? The mechanism that passes this value to the cog drops off the lower two bits (to squeeze it into 14 bits). By passing the address of a long (four bytes), we can be sure the lower two bits are always zero anyway, and will always be safe.

We know that the way the compiler assigns variables into the program space is so that those of the same type (long, word, or byte) will be stored in the order they appear in the listing. If the PASM code needs to deal with more than one hub address, we can use the address passed in ***par*** as the base and easily calculate the addresses of the other locations.

BLINKY, BLINKY LITTLE LED

Yeah, yeah, I know ... blinking an LED is as fun as eating chalk. Still, by creating a little demo we can start to get our heads wrapped around creating PASM-based objects and — let's face it — there are plenty of times in real applications where we need to blink an LED (or control some other element in a similar fashion) without having to worry that the timing will affect the rest of the program.

We cannot get to where we're going unless we know where that place is. Therefore, it is always a good idea — even for personal projects — to define a set of specifications before we start coding. With that, let's make these decisions about our blinker object:

1. We can define the pin number to blink.
2. We can define the "on" timing (in milliseconds).
3. We can define the "off" timing (in milliseconds).

The reason for items 2 and 3 is that with them, we can control the frequency and duty cycle of the modulated output.

Suggestion #2: *PASM code should not rely on modifications by the high level code before launching into the cog.*

This is a reiteration of what I described above and a rebuke of the way I have done things in the past. For example, in my less enlightened days I would have my Spin program make updates to the PASM code before it was launched into its own cog. This is bad form and I won't ever do it again. If you've done it, stop. If you're new to PASM, just stick with suggestion #2.

Writing code is sometimes like watching a Quentin Tarantino movie. There's a linear story but we don't approach it that way at first. Let's jump in by creating three variables that match our specifications. While we're at it, we'll also create a variable to hold the cog where the PASM code is running:

```
var

  long  cog
  long  blinkpin
  long  ontiming
  long  offtiming
```

Earlier, I stated that it always takes a bit of Spin code to launch a PASM program. In a full-blown object, we will typically wrap this in a method called **start**:

```
pub start(pin, onms, offms)

  stop

  blinkpin := pin
  ontiming := clkfreq / 1000 * onms
  offtiming := clkfreq / 1000 * offms

  cog := cognew(@blinker, @blinkpin) + 1

  return cog
```

Note that the **start** method accepts three parameters per our specification, and that the first thing it does is call the **stop** method. Let's go there:

```
pub stop

  if (cog)
    cogstop(cog - 1)
    cog := 0
```

The **stop** method is important because it allows us to

release a cog when it is no longer needed or — if we desire — to stop a cog running old parameters before restarting it (in most objects, we will pass parameter updates to a running cog but we're keeping this one very simple).

The **stop** method checks to see if the variable called cog is non-zero; if that is the case, it will stop the correct cog. The reason for the "— 1" in the **cogstop** instruction is that cogs are actually numbered from 0 to 7 (more on this in a second). When the cog is stopped, we reset the variable to zero so that another call to the **stop** method will not use **cogstop**.

For new Spin programmers, you may be wondering about the first time through. Spin clears all variables in the global space of an object to zero; this means that the first call to **stop** will simply return.

Getting back to the **start** method, we copy the pin parameter and then convert the milliseconds timing values to system ticks. In the Propeller, all timing is done in system ticks via the ***cnt*** register, most often using the **waitcnt** instruction. By dividing the system frequency (in ***clkfreq***) by 1,000, we get the number of clock ticks per millisecond. This is multiplied by the milliseconds in the cycle which gives us the number of clock ticks in the cycle.

Finally, we're down to launching the code with this:

```
cog := cognew(@blinker, @blinkpin) + 1
```

By now, you understand why we add one to the return value of **cognew**. The cogs are numbered 0 to 7 and if the **cognew** instruction was successful, that's what we get back. If there are no free cogs, then **cognew** will return -1. By adding one, we get zero which Spin evaluates as FALSE (any non-zero value is evaluated as TRUE). What this means, then, is that a successfully launched blinker cog will set the *cog* variable between 1 and 8; all of these (non-zero) values evaluate as TRUE. We return this to the caller so that it can deal with the success or failure of the **start** method.

Time to look at the PASM code. This is placed into our listing in a **DAT** section, usually after the Spin interface methods:

```
dat

                org     0

blinker         mov     t1, par
                rdlong  t2, t1
                mov     pinmask, #1
                shl     pinmask, t2

                add     t1, #4
                rdlong  ontix, t1

                add     t1, #4
                rdlong  offtix, t1
```

The first thing to do is copy the parameters from the hub to the RAM of our cog. The first instruction copies (using **mov**) the value in the ***par*** register to cog variable *t1*. Remember that ***par*** holds the hub address of the variable with the blinker pin.

Before moving on, we need to understand that all I/O control in the Propeller is accomplished using a bit mask; there is no direct bit access to a pin using dot notation (as we have done with the SX and other processors). While this may seem odd, using a mask allows us to set or clear one or many pins in a single instruction. For our program, then, we will have a cog variable called *pinmask* for output control.

To create the mask, we read the pin number from the hub into cog variable *t2*. Next, we move one (#1) into *pinmask* and then shift this value left by the pin number. With this mask, we can turn an output on or off using the appropriate instructions.

We need two more values from the hub. Remember that we moved the address stored in ***par*** to *t1*. To get the address of the next long in the hub, we can simply add four to *t1*. Why four? We have to do this because the cog sees the hub as an array of bytes and there are four bytes in a long. For each successive long we desire to transfer to the cog, we will add four; this is how we get the hub addresses for the variables holding the values for *ontix* and *offtix*. As with the pin number, the **rdlong** instruction transfers a long from the hub to the cog.

Okay, with parameters in place we can actually do something with *pin*. The first thing, though, is to set its bit in the directions register (***dira***) to output mode. We'll also start with the on portion of the cycle:

```
                or      dira, pinmask
                or      outa, pinmask
```

By ORing the pin mask with the directions and output registers, we set that pin into output mode and make it go high. We could have used **mov** here, but I tend to use instructions that will not affect other pins; I think this is good habit, especially as we get into processes that deal with multiple I/O.

To control the blink, we have specified timing for the on and off cycles in terms of system counts. One of my favorite aspects of the Propeller is that the system counter (available to us via the ***cnt*** register) makes timing a breeze — no more cycle counting to create a specified delay!

Most timing chores are handled with the **waitcnt** instruction. Now, we have to be careful with this as it doesn't work the way we might first expect (that is, it doesn't work like **PAUSE**); the **waitcnt** instruction waits for a specific value in the ***cnt*** register. What this means for us is that we need to add our timing (in ticks) to the present value of ***cnt*** so that we can wait for that target. Let's start the blink cycle timer:

```
              mov     timer, ontix
              add     timer, cnt
```

As you can see, we actually reversed the order of my description. We moved the value we want to wait into our timer variable and then added the current value of the ***cnt*** register to it. After that second line, we are in sync with the system counter vis-a-vis the **waitcnt** instruction.

Finally, we are ready to drop into the main loop:

```
blinkloop       waitcnt timer, offtix
                 andn    outa, pinmask
                 waitcnt timer, ontix
                 or      outa, pinmask
                 jmp     #blinkloop
```

When we enter the loop, the output is already on so we will use **waitcnt** to let the on timing expire. Note the second parameter of the **waitcnt** instruction: This is the value to add to the timer variable for the next **waitcnt**. So after the on time expires, we reload *timer* with the value for the off time.

To turn the pin off, we will use **andn** (and not) with the pin mask. I really like this instruction because it allows us to use the same mask to set pins low (in other variants of assembly, we would have to create a complimentary mask to clear pins using **and**). With the pin now low, we allow the off period to expire, reload the timer for the on period, turn the pin on, and then jump back to the top.

Before we walk away from this, we need to declare the variables used in our PASM code. In PASM, we tend to put these at the end of the listing. Here's what we have:

```
pinmask         res     1
ontix           res     1
offtix          res     1
timer           res     1

t1               res     1
t2               res     1

                 fit     496
```

All variables in the PASM code are longs, and the cog sees itself as an array of 512 longs. The **res** keyword reserves a slot in this RAM space for a variable (without consuming space when the code is stored in the hub). Unlike global variables in Spin, PASM variables are not initialized — we need to remember to initialize them before use. You'll also see that the end of the listing uses the **fit** instruction. This causes the compiler to ensure that the code and declared variables will actually fit into the cog. Why 496? Each cog has 16 special-purpose registers that must be accounted for, including ***par***, ***dira***, ***outa***, etc.

Something that new PASM programmers run into is the limit of constant values in code. Each PASM instruction has a nine-bit source and nine-bit destination value. When these are pointing to variables, we have no problems since we can hold 0 to 511 in nine bits, and that works having only 512 longs in the cog. For immediate values, however, this poses a restriction. How do we get around it? We define a PASM constant:

```
HxFFFF          long    $FFFF
```

While I'm calling this a constant, everything in the cog is in RAM, hence can be modified; what we're really doing is creating a pre-initialized variable. In the example above, we might use this as a mask to clear the upper 16 bits of another variable.

```
                        and     somevariable, HxFFFF
```

Important note: Pre-initialized variables (constants) must appear above reserved variable space in the PASM listing. This has to do with the way the compiler stores code in the hub on download. The structure of a PASM program is:

code
pre-initialized values (constants)
reserved space for variables
fit

Okay, we crawled through that one and yet we have a firm grip on building a PASM program and launching it. My friend, Peter, often reminds me not to optimize early and with that I will address what you advanced programmers are questioning: Why do we need the global variables for the pin number and for the on and off timing? That fact is that we don't.

This program expects to receive the first address of three longs; in the longs, are the pin number to blink, the on timing in system ticks, and then the off timing in system ticks. As we have passed three parameters using the **start** method, we can simply reuse them. The only thing to do is convert the timing parameters to milliseconds. The optimized **start** method becomes:

```
pub start(pin, onms, offms)

  stop

  onms *= clkfreq / 1000
  offms *= clkfreq / 1000

  cog := cognew(@blinker, @pin)
  return cog
```

By doing this, we've saved three longs. Again, don't optimize too early; get things working in the most straightforward fashion and then look for opportunities to optimize the use of system resources.

Sending information to a cog is fine, but how do we get it back, as in the case of a sensor? Again, keeping to suggestion #1 we will do everything via the ***par*** register. Of course, using ***par*** we can set up any number of hub addresses in our PASM code for direct access. Let's keep things simple, though, and stick with ***par*** for the back-and-forth mechanism.

Those of us that came from PBASIC are used to pin instructions like **HIGH**, **LOW**, **TOGGLE**, and **INPUT**. These don't exist in Spin, though they are easy to recreate. For example, I have a method in my standard Spin template that looks like this:

```
pub high(pin)

  outa[pin] := 1
  dira[pin] := 1
```

Of course, under the hood the Propeller is converting my pin number to a mask and applying it to the ***outa*** and ***dira*** registers. I also have this code:

```
pub input(pin)

  dira[pin] := 0

  return ina[pin]
```

This sets the desired pin to input mode and returns its present state (0 or 1) to the caller. As an exercise, let's move my **HIGH**, **LOW**, **TOGGLE**, and **INPUT** instructions to PASM as a simple demonstration of back-and-forth communications with a PASM cog.

If we think about it for a moment, we have two values to pass to the cog: 1) a command value (what we want to do), and 2) the pin number affected by that command. We could, of course, use two longs to handle this but that seems a bit silly; we only have 32 pins, so that will fit into a byte, and we only have four commands, so that will fit into a byte, too. What we can do, then, is compress these values into a single long (pointed to by ***par***).

Starting the I/O cog is really easy because it only requires a pointer to a hub variable that will hold the command and the result of a request for a pin's state. You'll find this in the **start** method:

```
  cog := cognew(@io, @iocmd) + 1
```

Of course, *cog* and *iocmd* are global variables in the object. Let's have a look at one of the methods that provides an interface to the PASM code:

```
pub high(pin)

  iocmd := (pin << 8) | 1
```

Easy: We move the pin number and the command (1) into *iocmd*. By shifting the pin number left by eight bits, we are moving it into byte1 of the command. That's it. The PASM cog is constantly monitoring the value in *iocmd* acting on it. Let's see how that's done:

```
dat

                org     0

io              rdlong  cmd, par
                mov     iopin, cmd
                and     cmd, #$FF  wz
          if_z  jmp     #io
```

We start by reading the [compressed] command from the address in ***par***. Since this value holds the command and the pin number, we'll copy it into the variable *iopin* for later use. Then, we strip off the pin number by ANDing the command with $FF; note that inline constants and addresses are prefaced with # in PASM. Note, too, that we are going to allow the zero flag to be modified by this instruction. If the result of the AND operation is zero, the z-flag will be set. In the next instruction, we check the z-flag and if it is set then we jump back to the top; a zero in the low byte of the command means that there is no command.

Assuming the low byte is not zero, the code drops through and we can convert the pin number to a mask for use in affecting the I/O:

```
                shr     iopin, #8
                mov     pinmask, #1
                shl     pinmask, iopin
```

The Spin interface shifted the pin number to the left by eight bits so to recover it, we shift right by eight bits. After that, we can use this value to create a mask for the pin as we did before.

The next step is to validate the command. For a simple program like this using very few commands, it is easiest to do a compare-and-jump type process:

```
                cmp     cmd, #1  wz
          if_e  jmp     #cmdhigh

                cmp     cmd, #2  wz
          if_e  jmp     #cmdlow

                cmp     cmd, #3  wz
          if_e  jmp     #cmdtoggle
```

```
                cmp     cmd, #4  wz
        if_e    jmp     #cmdinput
```

The **cmp** (compare) instruction works by subtracting the source field from the destination field and updating either of the flags that have been enabled, without actually affecting the destination field. When two values are equal, the result is zero so we want to set or clear the z-flag for our comparisons. If the command is equal to the test value, then we jump to the handler for the command.

What happens if we manage to pass a bogus command value? This will cause the program to drop through all the valid tests to this section which clears the lower byte of the command and then writes it back to the hub:

```
cmdexit         andn    cmd, #$FF
                wrlong  cmd, par
                jmp     #io
```

Here's that cool **andn** instruction again; in this case, we're clearing the lower eight bits (low byte) of the command variable. This is written back to the hub before we head back to the top to look for another command.

Okay, then, let's look at a couple of instructions — the first will set a pin high:

```
cmdhigh         or      outa, pinmask
                or      dira, pinmask
                jmp     #cmdexit
```

With the work we did on the blinker program, this should make perfect sense. Using the previously-created mask, we update the ***outa*** register to enable the output bit and then make that pin an output by updating the ***dira*** register. Then, we jump to *cmdexit* to clear the command and wait for another.

How about reading a pin?

```
cmdinput        andn    dira, pinmask
                mov     cmd, #0
                test    pinmask, ina  wc
                muxc    cmd, #%1_0000_0000
                jmp     #cmdexit
```

Here, we start by clearing the bit in the ***dira*** register so that the pin is forced to input mode. Next, we clear the *cmd* variable which removes the pin and command numbers. Now, we can read the pin by using the **test** instruction. This works by ANDing the pin mask with the inputs register (***ina***) and writing the result to the carry flag. In this instruction, we must place ***ina*** in the source field as it is a read-only register. If the input pin is high, we will end up setting the carry flag. Otherwise, it is cleared.

The next instruction, **muxc**, is really cool. What it does is copy the value of the carry flag to all the bits in *cmd* that correspond to 1s in the mask value in the source field. Since we're using the constant with only one bit set (bit8), that's the only bit that will receive the value of the carry flag.

Now, let's go back to the Spin interface for this command:

```
pub input(pin)

  iocmd := (pin << 8) | 4
  repeat until (iocmd.byte[0] == 0)

  return iocmd.byte[1]
```

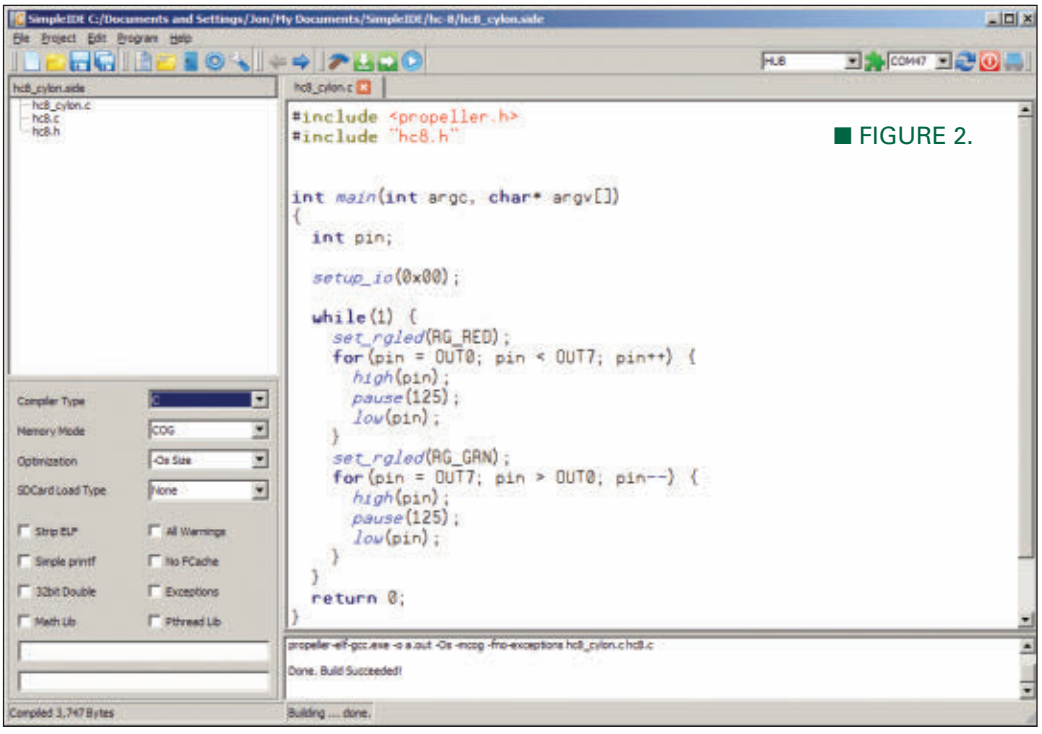
In this case, we want to wait on the PASM code to write the value back. After writing the command, we drop into a repeat loop that monitors the low byte of the command value. When we detect zero here, we know the command is finished and we can return the result that is sitting in byte1.

OH SAY CAN YOU C?

When the Propeller was released in 2006, Parallax took a bit of flack — perhaps, some of it fair — for not providing a C compiler for it. One cannot deny that C is the dominant programming language for systems large and small. I can understand C, and have even written a few small programs for PICs using it, but it's not my favorite language and I've found that Spin and PASM are great for my Propeller projects. Still, there are some — like my friend, Peter, for example — that just won't touch a new micro unless they can program it in C.

Well, they may be late, but Parallax has come though. To their credit, Parallax assembled an incredibly gifted team of embedded programmers to create a GCC port for the Propeller. This is great news for C programmers. You get to program in your favorite language and still get cool multi-core capabilities.

As I'm not a big C programmer, it would be a mistake for me to get too deep into this, but I did want to share the news. You may be wondering how all this works given the memory limitations of a cog (512 longs). The compiler lets you select the memory model for your project. Very small programs may, in fact, fit into a single cog and run full Assembly speed (there have been some interesting drivers written in C — a great demonstration as to how well the compiler works). Larger programs can use a model called LMM (large memory model). In this case, a cog is loaded with a small program that reads and executes assembly instructions that are stored in the hub. Of course, LMM code doesn't run as fast as cog code (it runs at about 25% full speed), but it is much faster than interpreted Spin code. There are



■ FIGURE 2.

also options called XMM (eternal memory model) since some nifty folks have come up with mechanisms for adding external program data space to the Propeller.

For you Arduino fans wanting more horsepower ... good news! One advanced forum member is working on a port of the Arduino standard library to the Propeller for PropGCC.

With distinct hardware differences, I don't know that all Arduino programs will compile and run under PropGCC without modification, but this effort will certainly give those Arduino users a leg-up when wanting to try the Propeller.

You may remember a few issues back that I mentioned the Propeller ASC (Arduino Shield Compatible) board — with this, you can use (most of) your existing shields and experience the power of the Propeller using a lot of the code you already have.

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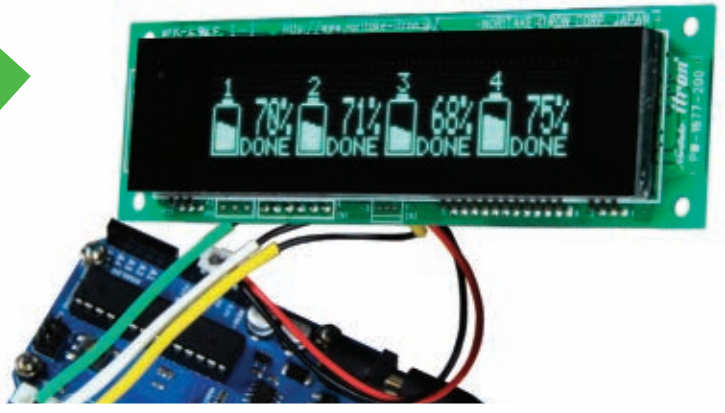
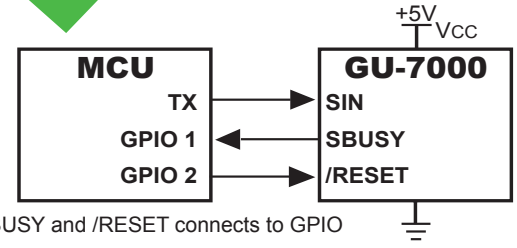


Common serial interface
• UART • USART • SPI
UART example shown



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THAT'S A WRAP

To wrap up, the reason I was chiding myself for past mistakes (i.e., allowing Spin code to modify PASM code before launching) and setting new rules for my PASM code is that PropGCC can actually use properly-crafted PASM objects (everything goes though ***par***). That's pretty cool! We can code a PASM object that works with Spin and if a client desires the application code in C, our effort is not lost. Of course, it takes a bit of work and I'm just getting the hang of it. Perhaps next time I'll do a dual project in Spin and C. I recently wrote a PASM driver for those surplus LCDs taken from Nokia cell phones and that might be fun to play with in both languages.

There's a lot of exciting stuff going on with PropGCC. For casual programmers like me, there is a nice little tool called SimpleIDE that makes getting started with PropGCC a breeze. I'm using the Windows version (see **Figure 2**), but there are also versions for Linux and Mac operating systems. Down the line, Parallax will be releasing an Eclipse plug-in for PropGCC that should make professional programmers very happy.

C programmers rejoice — you finally get to run your favorite language on a very cool microcontroller! And all for the cost of the time to download and run the installer. That's a price that's hard to beat.

Until next time, keep spinning and winning with the Propeller! **NV**

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- ✔ **Dual LED bar graph audio level meters!**
- ✔ **Automatic adjustable microphone ducking!**
- ✔ **Easy to build through-hole design!**

This professional synthesized transmitter is adjustable directly from the front panel with a large LED digital readout of the operating frequency. Just enter the setup mode and set your frequency. Once selected and locked you are assured of a rock stable carrier with zero drift. The power output is continuously adjustable throughout the power range of the model selected. In addition, a new layer of anti-static protection for the final RF amplifier stage and audio inputs has been added to protect you from sudden static and power surges.

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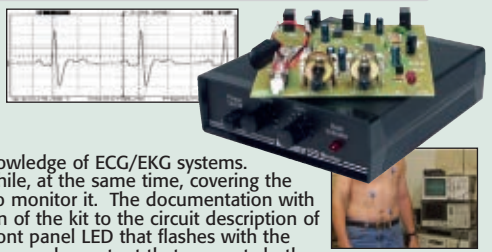
The FM100B series includes an attractive metal case, whip antenna and built in 110/220VAC power supply. A BNC connector is also provided for an external antenna. Check out our Tru-Match FM antenna kit, for the perfect mate to the FM100B transmitter. We also offer a high power kit as well as an export-only assembled version that provides a variable RF output power up to 1 watt. The 1 watt unit must utilize an external antenna properly matched to the operating frequency to maintain a proper VSWR to protect the transmitter.

(Note: The FM100B and FM100BEX are do-it-yourself learning kits that you assemble. The end user is responsible for complying with all FCC rules & regulations within the US or any regulations of their respective governing body. The FM100BWT is for export use and can only be shipped to locations outside the continental US, valid APO/FPO addresses or valid customs brokers for documented end delivery outside the continental US).

FM100B	**Super-Pro FM Stereo Radio Station Kit, 0-25mW**	**$269.95**
FM100BEX	**Super-Pro FM Stereo Radio Station Kit, 5uW to 1W**	**$349.95**

Electrocardiogram ECG Heart Monitor



- ✔ **Visible and audible display of your heart rhythm!**
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- ✔ **Simple and safe 9V battery operation**

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ECG1C	**Electrocardiogram Heart Monitor Kit With Case & Patches**	**$44.95**
ECG1WT	**Electrocardiogram Heart Monitor, Factory Assembled & Tested**	**$89.95**
ECGP10	**Electrocardiogram Re-Usable Probe Patches, 10-Pack**	**$7.95**

Laser Beam Audio Communicator

Now you can talk to your friends over one of the most secure long-distance transmission types available, a laser beam! The transmitter uses a microphone or external audio to modulate a laser beam on and off at a rate of more than 16kHz so the audio fidelity is much better than that of a standard 3kHz telephone line! The receiver includes filtering to remove the 16kHz carrier and leave behind the high quality audio, and then boost its level for use with earphones. Transmitter audio AGC keeps your level perfect! Includes transmitter, receiver and laser pointer. Each runs on a 9V battery.

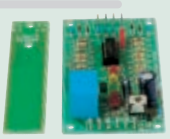
LBC6K	**Laser Beam Audio Communicator Kit**	**$59.95**

Laser Trip Senser Alarm

True laser protects over 500 yards! At last within the reach of the hobbyist, this neat kit uses a standard laser pointer (included) to provide both audible and visual alert of a broken path. 5A relay makes it simple to interface! Breakaway board to separate sections.

LTS1	**Laser Trip Sensor Alarm Kit**	**$29.95**

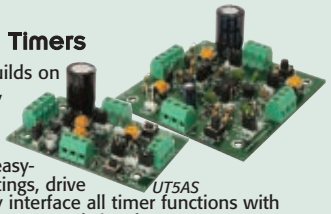
Liquid Level Controller



Not just an alarm, but gives you a LED display of low, middle, or high levels! You can also set it to sound an alarm at the high or low condition. Provides a 2A 240VAC rated relay output. Runs on 12-14VAC or 16-18VDC.

K2639	**Liquid Level Controller Kit**	**$21.95**

Ultimate 555 Timers



UT5AS

This new series builds on the classic UT5 kit, but takes it to a whole new level! You can configure it on the fly with easy-to-use jumper settings, drive relays, and directly interface all timer functions with onboard controls or external signals.

All connections are easily made though terminal blocks. Plus, we've replaced the ceramic capacitor of other timer kits with a Mylar capacitor which keeps your timings stable over a much wider range of voltages! Available in through hole or surface mount versions! Visit www.ramseykits.com for version details.

UT5A	**Through Hole 555 Timer/Osc Kit**	**$24.95**
UT5AS	**SMT 555 Timer/Osc Kit**	**$26.95**

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Finally, a compact USB PIC Programmer with a 20 pin ZIF socket for easy programming of most Microchip PIC Flash devices that does not require low voltage programming. Plus it uses USB therefore no more RS232 compatibility blues!

CK1301	**USB PIC Programmer Kit**	**$34.95**

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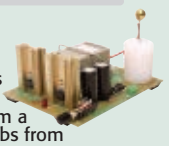
NIXIE	**Nixie Tube Clock Kits**	**from $139.95**

HV Plasma Generator



Generate 2" sparks to a handheld screwdriver! Light fluorescent tubes without wires! This plasma generator creates up to 25kV at 20kHz from a solid state circuit! Build plasma bulbs from regular bulbs and more! Runs on 16VAC or 5-24VDC.

PG13	**HV Plasma Generator Kit**	**$64.95**

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Need to "perk-up" your counter or other equipment to read weak signals? This preamp has low noise and yet provides 25dB gain from 1MHz to well over 1GHz. Output can reach 100mW! Runs on 12 volts AC or DC or the included 110VAC PS. Assmb.

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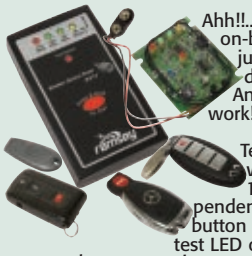
Four-Mode Vehicular Keyless Entry Test Set *"HANDIEST THING IN MY SHOP"*



Ahh!!... the conveniences of today's technology in our modern world! Voice recognition, LED's instead of incandescent bulbs, on-board computers, on-board hard drives, automatic parallel parking, automatic radar cruise control, and of course, wireless remote controls! They make it so simple, just have the "key" (called a key fob) somewhere in your pocket or purse, get near the vehicle, it knows that you are there! Touch the door handle and the vehicle unlocks. Get in and touch the start button and the vehicle starts. You have yet to use a key through the whole process! And don't forget all the wireless controls for your house lights, building access and entertainment systems. They're so great… until they don't work!

Testing your system is easy. To test the complete key fob-to-vehicle and vehicle-to-key fob communications path just stand close to the vehicle with the WCT3 and your key fob in hand. Press the test button and the WCT3 will detect and display the presence of the vehicle's 125kHz/20KHz signal and, if they "handshake", will also detect and display the presence of your key fob's 315MHz return signal. You can independently test key fob only signals (panic, lock, trunk, etc.) by holding the key fob near the WCT3, pressing the test button, and pushing the function button on the key fob. The same functionality testing can be done with IR key fobs. The modulated IR signal is detected and will illuminate the IR test LED on the test set. If you know a few "secrets" you can also see if the tire pressure sensors/transmitters are generating signals or the built-in garage door opener in your rear view mirror is transmitting a signal! But the WCT3's uses go beyond the automotive world. The majority of building wireless access systems also utilize 125 kHz. Just hold the test set near the building access sensor and the WCT3 will detect the 125 kHz signal. That will help you troubleshoot door access locations that are not working. It gets even better... you can use the WCT3 to test virtually any other 315 MHz, 433 MHz, 125kHz, 20kHz and IR wireless control system to verify generation of a signal. The WCT3 test set is housed in a compact 2.25" x 4.6" x 9" case and is powered by a standard 9VDC battery (not included).

WCT3 **Four Mode Keyless Entry Test Set Kit** **$59.95**

Passive Aircraft Monitor *PATENTED!*

The hit of the decade! Our patented receiver hears the entire aircraft band without any tuning! Passive design has no LO, therefore can be used on board aircraft! Perfect for airshows, hears the active traffic as it happens! Available kit or factory assembled.

ABM1 **Passive Aircraft Receiver Kit** **$89.95**

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The incredible OBDII plug-in monitor that has everyone talking! Once plugged into your vehicle it monitors up to 300 hours of trip data, from speed, braking, acceleration, RPM and a whole lot more. Reads and resets your check engine light, and more!

8226 **CarChip Pro OBDII Monitor-Asmb** **$79.00**

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The famous RF preamp that's been written up in the radio & electronics magazines! This super broadband preamp covers 100 KHz to 1000 MHz! Unconditionally stable gain is greater than 16dB while noise is less than 4dB! 50-75 ohm input. Runs on 12-15 VDC.

SA7 **RF Preamp Kit** **$19.95**

Touch Switch

Touch on, touch off, or momentary touch hold, it's your choice with this little kit! Uses CMOS technology. Actually includes TWO totally separate touch circuits on the board! Drives any low voltage load up to 100mA. Runs on 6-12 VDC.

TS1 **Touch Switch Kit** **$9.95**

Mad Blaster Warble Alarm

If you need to simply get attention, the "Mad Blaster" is the answer, producing a LOUD ear shattering raucous racket! Super for car and home alarms as well. Drives any speaker. Runs on 9-12VDC.

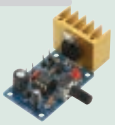
MB1 **Mad Blaster Warble Alarm Kit** **$9.95**

Laser Light Show

Just like the big concerts, you can impress your friends with your own laser light show! Audio input modulates the laser display to your favorite music! Adjustable pattern & speed. Runs on 6-12VDC.

LLS1 **Laser Light Show Kit** **$49.95**

PWM Motor Controller



This handy controller uses a pulse width modulated output to control the speed of a motor without sacrificing torque! Handles a continuous current of 5A and includes LED to indicate speed as well as an oversized gold heatsink! Also available factory assembled.

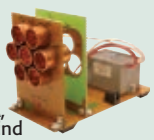
CK1102 **5A PWM Motor Controller Kit** **$14.95**

Digital LED Thermometer

This handy thermometer reads Celsius or Fahrenheit on an eye-catching .56" LED display! Based on the DS18B20 sensor and controlled by a PIC, it has a range of -67°F to 257°F (-55°C to 125°C) with a wired remote range of 325 feet!

CK127 **Digital LED Thermometer Kit** **$29.95**

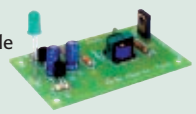
Air Blasting Ion Generator



Generates negative ions along with a hefty blast of fresh air, all without any noise! The steady state DC voltage generates 7.5kV DC negative at 400uA, and that's LOTS of ions! Includes 7 wind tubes for max air! Runs on 12-15VDC.

IG7 **Ion Generator Kit** **$64.95**

Tickle-Stick Shocker



The kit has a pulsing 80 volt tickle output and a mischievous blinking LED. And who can resist a blinking light and an unlabeled switch! Great fun for your desk, "Hey, I told you not to touch!" Runs on 3-6 VDC.

TS4 **Tickle Stick Kit** **$9.95**

Tri-Field Meter Kit *THE GHOST DETECTOR!*

"See" electrical, magnetic, and RF fields as a graphical LED display on the front panel! Use it to detect these fields in your house, find RF sources, you name it. Featured on CBS's Ghost Whisperer to detect the presence of ghosts! Req's 4 AAA batteries.

TFM3C **Tri-Field Meter Kit** **$74.95**

Speedy Speed Radar

Speed readout is on two LED displays which can be set accurately (better than 1%) to show MPH, kilometers-per-hour, or even feet-per-second. An earphone output allows you to hear the actual Doppler frequency shift of moving objects, the theory upon which all radars operate.

Uses two 13 oz. coffee or juice cans for antenna (not included)... so start drinking! Antenna unit can be remotely placed up to 300 feet away. The SG7 is easy and informative to build. All critical sections are PCB stripline and calibration is as easy as pointing the SG7 at a fluorescent lamp! Your Speedy kit includes a deluxe black ABS plastic case with SPEEDY graphics for a neat professional look. Operates on 12-15VDC.

SG7 ***Speedy*** **Speed Radar Gun Kit** **$69.95**

Electret Condenser Mic

This extremely sensitive 3/8" mic has a built-in FET preamplifier! It's a great replacement mic, or a perfect answer to add a mic to your project. Powered by 3-15VDC, and we even include coupling cap and a current limiting resistor! Extremely popular!

MC1 **Mini Electret Condenser Mic Kit** **$3.95**

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Starting out our "All in One" series, the PL130A, gives you 130 different electronic projects, together with a comprehensive 162 page learning manual. A great start for the kids...young and old! Next, check out the PL200, that gives you 200 very creative and fun projects, and includes a neat interactive front panel with 2 controls, speaker, LED display and a meter. From there, step up to our PL300, which gives you 300 separate electronic projects along with a 165 page learning and theory manual. The PL300 walks you through the learning phase of digital electronics. If you're looking for the ultimate lab kit, check out our PL500. It includes a whopping 500 separate projects, a 152 page starter course manual, a 78 page advanced course manual, and a 140 page programming course manual! The PL500 covers everything from the basics to digital programming!

If you are looking to either learn or hone up on your through hole or SMT soldering skills check our SP3B and SM200K Practical Soldering Labs. You will be a soldering master in no time!

We make it easy to learn IC's while at the same time, building a neat AM/FM radio with our AMFM108K AM/FM IC lab kit. You will have a blast AND learn!

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PL500	**500-In-One Lab Kit**	**$249.95**
SP1A	**Through Hold Soldering Lab**	**$9.95**
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AMFM108K	**AM/FM IC Lab Kit & Course**	**$34.95**

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Q&A

WHAT'S UP:

Join us as we delve into the basics of electronics as applied to every day problems, like:

- ✓ **Weston AC Ammeter**
- ✓ **Battery Internal Resistance**
- ✓ **Transformerless Power Supply**

■ WITH RUSSELL KINCAID

In this column, I answer questions about all aspects of electronics, including computer hardware, software, circuits, electronic theory, troubleshooting, and anything else of interest to the hobbyist. Feel free to participate with your questions, comments, or suggestions. **Send all questions and comments to: Q&A@nutsvolts.com**

RFID

Q The devices in **Figure 1** are on packages in stores. I think they are to warn of theft. How do they work? They appear to be a tuned circuit, but inactive.

— Vincent S. W. Dymek

A These are passive RFID (Radio Frequency Identification) devices which reflect a signal when energized by an RF field. Examination shows there are seven loops — all shorted together at one corner, with a blob in the center part. Since each loop is a different length, they will resonate at different frequencies, and an intelligent probe could recover a seven-digit code. I don't know what the function of the blob is; they have raised bumps and I don't see how that could contain any data. These are not programmable and not hackable; they cannot be used as a theft deterrent because they cannot be turned off. I believe this type of RFID is strictly for inventory control.

Another type of RFID has memory and can be programmed. They do not have a battery; power is obtained from the RF probe. I don't know how these work either but since they are programmed, they are hackable; in fact, there are websites that advertise hacking tools for sale. There are also websites that advertise conductive pockets that you can put your hackable credit card or passport in to prevent access. I assume that the data on credit cards and passports will be encrypted, but I don't believe anyone has devised a code that cannot be broken.

■ FIGURE 1.

POWER SUPPLY: 1.5V, 15A

Q I need some information on an isolated 12 volt to 1.5 VDC DC-to-DC converter. The input range is 9-18V; output is 15A at 1.5V — 15A output, no minimum load, push pull driver, full wave diode on output. The converter I need is for a battery eliminator for tube filament in vacuum tubes. I need a parts list and schematic. Thanks.

— Sandraq Ramsey

A The power output is 22.5 watts and assuming 80% efficiency, the input is 28 watts. I want to use Micrometals core F42510-EC because I have some. First, I need to check that it can handle the power which depends on the core crossection (Ac) and the window area (Wa):

WaAc = 5.28*10^-3*Po*10^8/B/F

where Po = power output (watts)
B = flux density (gauss) = 1,000
F = frequency (Hz) = 100 kHz
WaAc = .121

From the catalog, WaAc for the core is .162, so it is okay. The core loss for F material and 100 kHz is 100 mW/cm^3; this multiplied by the core volume of 1.87 cm^3 gives 0.187 watts loss. The primary turns are computed from:

Np = Vp*10^8/4/B/A/F

where Vp = primary voltage = 18V
B = flux density = 1,000
A = core cross-section = .385
F = frequency = 100 kHz
Np =12

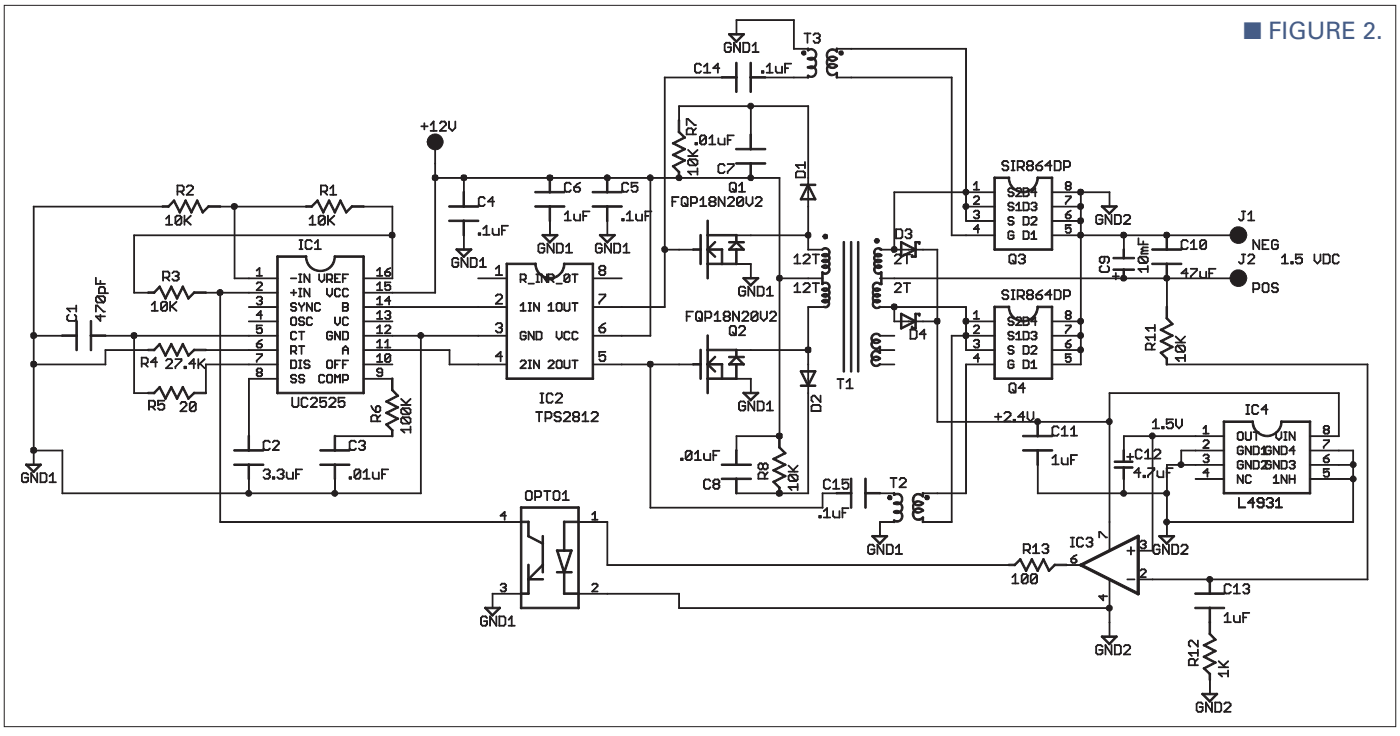
Now, I like to check that the magnetizing current (= Vp/Xlp) is less than 10% of the operating current. The operating current is 28W/9V = 3.1 amps; the inductance of the primary is:

Lp = Np^2*Al*10^-6

where Al = 2.3 henries/1,000 turns
Lp = 331 uH
Xlp = 6.28*Lp*F = 208 ohms

Therefore, the magnetizing current

■ FIGURE 2.



is Vp/Xlp = 18/208 = 87 mA; that's okay. Now, the secondary turns are just the voltage ratio: Ns = Vs*Np/Vp = 1.5*12/9 = 2 turns. The wire size can be computed from:

AWG = -4.31* ln(1.889*I/Cd)

where ln = natural logarithim
Cd = current density = 400 A/cm^2
I = the current (amps)

The primary wire is #18 (.00823 sq cm). The secondary wire is #12 (.0331 sq cm). These turns should fit in the window area (0.42 cm^2).

- 12 * .00823*2 = .296 (times 2 because the supply will be push-pull, see **Figure 2**).
- 2 * .0331 = .0662
- Total = .362

which will fit, although it is tight. If Cd is set at 600A/cm^2, AWG = #20 for the primary (.0052 sq cm), making the total: .190 cm^2, which is much better and the efficiency will not be significantly reduced.

That was the hard part; the easy part is drawing the circuit diagram (see **Figure 2**). The datasheet gives the circuit, so it is just a matter of tailoring it to our needs. C1 and R4 set the frequency; in this case, 100 kHz. I have a lot of trouble with stabilization compensation. The datasheet shows the open loop gain is 40 dB with a 100K load, so I set the corner frequency of R6, C3 at 100 Hz. I don't want the rolloff of the output capacitors to add to the rolloff of the error amp at 100 kHz. I am concerned that the gain is still too high, so I added R12, C13 with a corner frequency of 100 Hz. If I am right, the open loop gain will reach 0 dB with a slope of 6 dB per octave (which is necessary for stability).

The power MOSFETs are rated 200 volts, so the snubbers D1, R7, and C7 may not be necessary but they are cheap insurance. I want to use synchronous rectification to improve efficiency; if I use Schottky diodes for the output rectifiers, the power loss is .5V x 15A = 7.5 watts. However, using MOSFET switches, the loss is 15^2 x .0036 ohms = 0.81 watts. The capacitors C14 and C15 prevent saturation of the pulse transformers due to the DC pulses from IC2.

The builder will have to pay attention to transformer polarity so that the synchronous switches turn on at the right time. Since the N-MOS switch has an internal reverse diode, it is necessary to turn on the switch when the source is being driven negative; this drives the center tap positive. The **diagram** shows a third winding because I initially thought I would need a higher voltage winding to power the secondary control circuit; but I realized that three volts was available from the secondary which is sufficient to power the circuit. I have built the primary side before but have not built a synchronous rectifier, so some tweaking may be required. The Parts List is shown in **Figure 3**.

WESTON AC AMMETER

Q I own a Weston AC ammeter. It's old but it works great. Best I can tell, it is a model 433 with three ranges: 0 to 2.5; 1 to 5; and 2 to 10 amps.

Now my question: Can you tell me how to convert it to an mA meter instead of a straight AC ammeter? I would like it to read up to 1,000 mA. Probably the scales would not have to be changed; just add 10 to everything. The scales are selected by a knob on the right side of the meter and are labeled: Low, Med, High, and SC. Perhaps you might know what "SC" means.

Thank you for any help you can

PARTS LIST

■ FIGURE 3.

PART	DESCRIPTION	PKG	MOUSER PART #	COST EA
ALL RESISTORS ARE SURFACE MOUNT		1206	71-CRCW1206-CODE-E3	0.09
NOTE: CODE IS THE VALUE: 22.1, 221, 2.21K, 22.1K, 221K, 2.21M, ETC.				
C1	470 pF, 50V, 5%, COG	0805	80-C0805C471J1G	0.11
C2	3.3 µF, 25V, 10%, X5R	1206	810-C3216X5R1E335K11	0.32
C3	.01 µF, 50V, 5%, X7R	0805	80-C0805C103J5R	0.07
C4, C5, C14, C15	0.1 µF, 50V, 10%, X7R	1206	140-CC502B104K-RC	0.09
C6, C11, C13	1 µF, 50V, 20%, X5R	1206	810-C3216X5R1H105M	0.17
C7, C8	.01 µF, 630V, 20%, X7R	1206	810-C3216X7R2J103M	0.21
C9	10,000 µF, 6.3V, 20%, .02 OHMS	18MMX7.5	647-UPW0J103MHD6	1.39
C10	47 µF, 6.3V, CERAMIC	1210	81-GRM32ER60J476ME20	1.38
C12	4.7 µF, 50V, 20%, ALUM	5MMX2	647-UVZ1H4R7MDD	0.15
IC1	UC2525 PWM REGULATOR	SO16W	595-UC2525ADW	3.47
IC2	TPS2812 DUAL FET DRIVER	SO8	595-TPS2812D	2.17
IC3	OP-AMP, 2.4V, MC33201	SO8	863-MC33201DG	0.87
IC4	VOLT REF, 1.5V, L4931	SO8	511-L4931ABD15	1.30
Q1, Q2	N-FET, 200V, 20A	TO-220	511-STP20NF20	1.89
Q3, Q4	N-FET, 30V, 22A	SO8 PWR	781-SIR864DP-T1-GE3	0.65
D1, D2	600V, 1A, SMD, ES1J	DO-214AC	512-ES1J 0.54	
D3, D4	30V, 200 mA, SCHOTTKY	SOT23	512-BAT540.09	
OPTO1	TRANSISTOR, 80V, GAAS	GULL WING	557-PS2501L-1-A	0.46
T1	CORE: P45724-EC, BOBBIN: B5724-01, PRI: 24T CT #20, SEC: 4T CT #14			
T2, T3	PULSE XFMR, 1:1, 10 µS	6_PAD	580-7860116MC	1.79

give. Any changes or added circuitry would have to be external because I can't open the meter. The two center holes on the front are filled with the same material as the meter case and have the letter "w" in them. I suppose there could be a screw under the letter w but I would have to destroy the material to get to any screw.

— Frank M. Lemon

A What you have is an iron vane AC meter. It measures DC also; the reason it does not measure below 25 Hz is that the needle wavers at the AC frequency. I found a museum site that says it sold originally for $102.95. You could have it measure higher current by using a shunt, but it is not practical to have it measure smaller current. If you want, you can find a Weston model 433 milliammeter on eBay. These meters can be calibrated to better than 1% accuracy and are available for $25 to $100.

If you remove the material over the screws in the center, it will void the warranty but you don't have to worry about that now. The SC on the knob stands for "short circuit;" it takes the meter out of the circuit.

TRANSFORMERLESS POWER SUPPLY

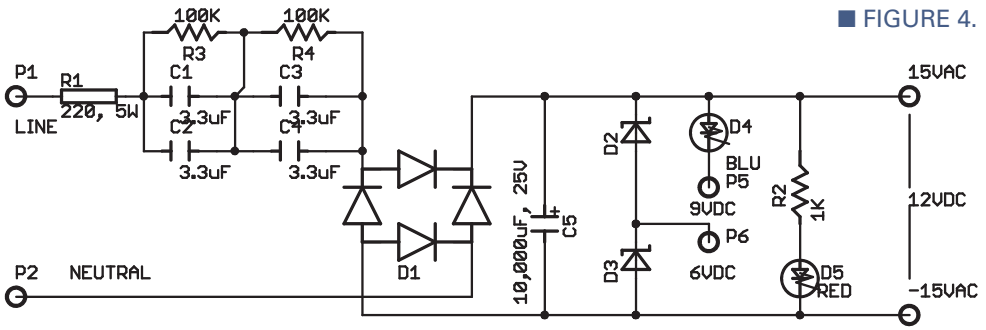
Q You recently helped a *Nuts & Volts* reader concerning a 220 VAC power supply and now I also would like to be helped ... in reverse with a 220 VAC transformerless power supply to be redesigned in order to be powered from 110 VAC. The desired output is 12 VDC at 50 mA.

I have a schematic of a 220 VAC transformerless power supply which I would like to build with parts from Mouser, but have it modified to work from 110 VAC. Please specify the value and wattage of components.

— Michael Williams

A I have redrawn your schematic (see **Figure 4**). I have assumed that the six volt and nine volt outputs are 10 mA max each for a total load of 70 mA. The zeners D2 and D3 will need 10 mA to provide a stable output, so the total input current is 80 mA. The current is limited by the impedance of C1, C2, C3, C4, and R1. The input current is AC, so a non-polar capacitor is needed but the highest voltage rating available is 100 volts, and 200 volts is needed. I put two in series to get a 200 volt rating, but now the capacitance is half and two more are needed to bring the capacitance back to 3.3 µF. The 100K resistors help insure that the voltage divides evenly

■ FIGURE 4.



TRANSFORMERLESS POWER SUPPLY PARTS LIST

PART	DESCRIPTION	PART NUMBER	PRICE EA
R1	220 OHMS, 5W, 5%	594-AC05W220R0J	$0.51
R2	1K, 1/4W, 5%	71-RN55D-F-1K	$0.09
R3, R4	100K, 1/4W, 5%	71-RN55D-F-100K	$0.09
C1, C2, C3, C4	3.3uF, 100V, 20%	647-UVP2A3R3MED	$0.27
C5	10,000uF, 25V, 20%	5985-25V10000	$3.82
D1	BRIDGE, 400V, 1A, DIP-4	6583-DB104	$0.44
D2, D3	6.2V, 5%, DO-41	771-1N4735A, 133	$0.04
D4	BLUE LED, 30mA MAX	941-C5SMFBJSCROV0532	$0.19
D5	RED LED, T1 3/4	604-WP7113SRD/F	$0.34

between the caps. R1 is for inrush current limiting. The calculated power is 1.5 watts but the Parts List calls for five watts to allow for overload without having it burn up. Using the equation: delta E = I*delta T/C, I calculate C = 6,400 µF for 0.1V ripple (T = 8.3 mS, I = 80 mA). Zener diodes D2 and D3 are 6.2 volts, providing 12.4 volts nominal at the output. If there is no load, the two zener diodes will have to carry the entire 80 mA. The power dissipation is .99 watts and the diodes are rated one watt each so that's okay.

The output terminals have 15 VAC on them, so cannot be connected to earth ground. If the line and neutral connections were swapped, the output terminals will be at 95 VAC, so I would put the circuit and load in a box so that users cannot get shocked.

BATTERY INTERNAL RESISTANCE

Q Regarding the circuit in **Figure 5** from the February '12 issue, can you please explain how we can measure the battery internal resistance — the theory?

Also, what should the internal resistance value be for a new battery and used battery?

— Sam Botros

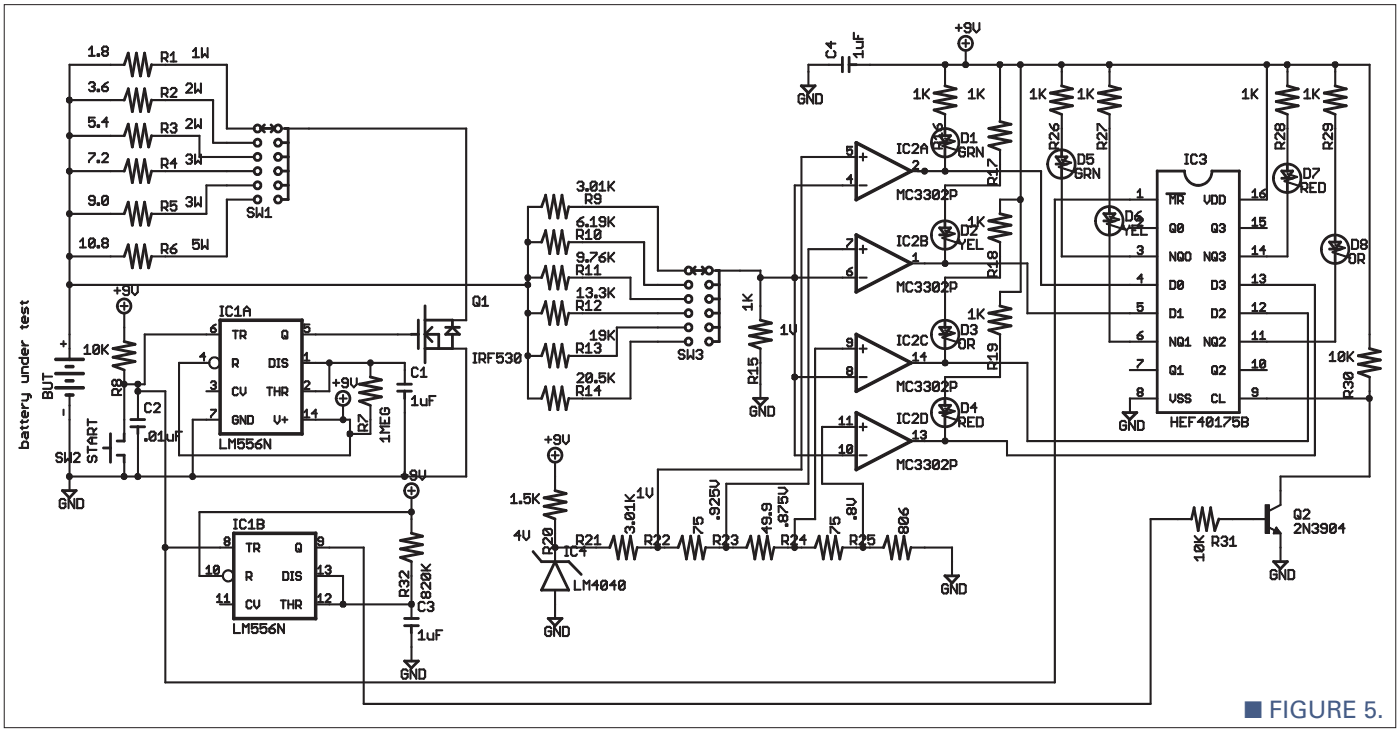
A To measure the battery internal resistance, load the battery with a resistance R1 and measure the output voltage V1, then use a larger resistor R2 and measure the output voltage V2. The voltage difference V2-V1 divided by the current difference gives I2-I1 as the output resistance; I1= V1/R1 as always. If the output resistance was linear (not likely), you could measure the open circuit voltage then the loaded voltage, and compute the output resistance from (Vo-V1)/I.

You can use this method to measure any unknown resistor, particularly when the resistance is less than one ohm because the ohmmeter measures its own wire resistance plus the unknown. In this case, you would measure the input voltage V0 and the load voltage V1, compute the current I = V1/R, then compute the resistance as Runk = (V0-V1)/I.

According to the *Energizer Technical Bulletin*, the typical effective resistance of fresh Energizer alkaline cylindrical batteries (using a 5 mA stabilization drain followed by a 505 mA 100 mS pulse) will be approximately 150 to 300 milliohms, depending on size. The internal resistance increases at low temperature, more than doubling between room temp and -20 deg C.

Battery University (**www.batteryuniversity.com**) compares Ni-Cad, nickel-metal-hydride, and lithium-ion for internal resistance and run time. The nickel-cadmium has the lowest internal resistance at .155 ohms; the lithium-ion is next at .32 ohms; and the nickel-metal-hydride is highest at .778 ohms. In their test, Ni-Cad ran 120 minutes at 3C (C is the rated current); lithium-ion ran about 50 min at 3C; and nickel-metal-hydride did not work at 3C but ran 60 min at 2C. The internal resistance of nickel-metal-hydride at discharge is about .34 ohms, reduces to .28 ohms at half charge, and increases to about .34 ohms at full charge. However, the resistance at full charge drops to .3 ohms after resting for two hours. The resistance of lithium-ion is fairly flat over the charge/discharge range (.27 to .25 ohms).

The internal resistance of lead-acid gel cells (like those used in wheel chairs) runs from .009 ohms at full charge to .015 ohms when discharged. **NV**



■ FIGURE 5.

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For more information, contact:
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The Pmod Shield-Uno has five 2x6 Pmod connectors. It also provides access to the I/O connectors on the Uno32, as well as connecting to the I²C bus supported by the Uno32. When used together, the Pmod Shield-Uno and the Uno32 let both Arduino-style shields and Digilent Pmods use all the features of the Microchip PIC32MX320F128H microcontroller on the Uno32.

Digilent's chipKIT development platform is a 32-bit Arduino-style solution that enables hobbyists and academics to easily and inexpensively integrate electronics into their projects, even if they do not have an engineering background. The platform consists of two PIC32-based development boards and open source software that is compatible with the Arduino programming language and development environment.

Digilent's chipKIT hardware is compatible with existing 3.3V Arduino shields and applications, and can be developed using a modified version of the Arduino IDE and existing Arduino resources such as code examples, libraries, references, and tutorials. The chipKIT Pmod Shield-Uno is available for $26.95.

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BLUETOOTH DEVICES

The Parani-MSP1000 available from Lemos International Co., Inc., is a Bluetooth access point which enables Bluetooth devices to be connected to 10/100 Mbps Ethernet networks.

The Parani-MSP1000 supports seven, 14, and 28 Bluetooth connections according to the model, and it supports up to 3 Mbps throughput through Bluetooth 2.0+EDR specification. The Parani-MSP1000 is a class 1 Bluetooth device that supports 150 m using basic dipole antennas and up to 1 km using patch antennas.

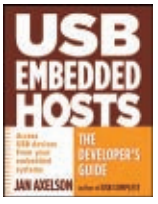
It supports such profiles as serial port, LAN access, PAN, and FTP for various applications. For ideal serial cable replacement applications, Lemos provides free COM/TTY port redirector software for Windows/Linux.

Continued on page 77

SHOWCASE

Access USB Devices from Small Systems

USB isn't just for PCs. Learn how your small systems can access USB drives, keyboards, printers, speakers, network bridges, cameras, and more.



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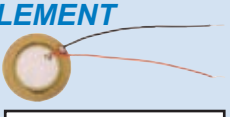

50mm wire leads.

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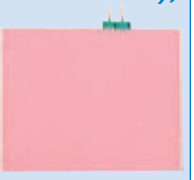
EL BACKLIGHT (GLOW STRIP), 2.8" X 2.2"



Used for backlighting displays, control panels, special effects and model lighting. Flexible, produces practically no heat. Operates on 80-120Vac and will run off of inverter or standard "house" electricity. Salmon color in off-state. Glows white when energized. Solderable pins.

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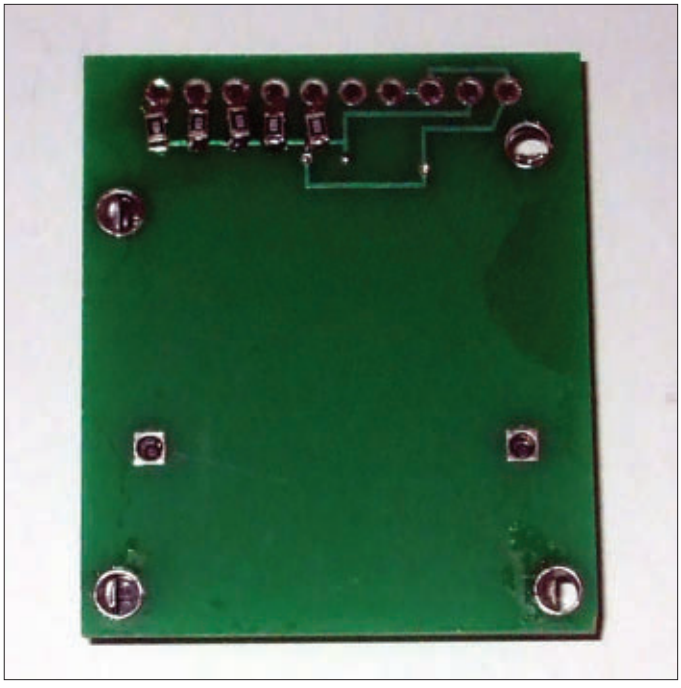
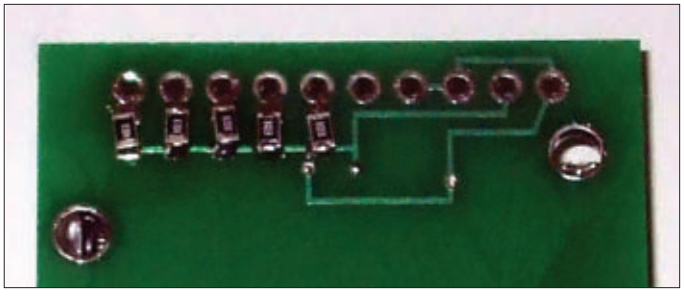
BUILD THE POOR MAN'S SEISMOGRAPH

By Ron Newton

Now that other states (like Washington D.C.) know they are not exempt from earthquakes, more people are interested in seismic activity. Personally, I have been using seismographs most of my life. I actually have three in my back garage. In this article, I will present an old school way of performing measurements with an updated, yet simple seismograph that can be used anywhere.



■ **FIGURE 1.**



This is a really great project for science fairs and for those who wish to do their first soldering project; check out **Schematic 1**. There are only a couple of surface-mount 805 resistors to install (see **Figure 1**).

When I started writing this article, I thought I would use the standard Geo Phone that (back in 1999) could be purchased used for $8. Now, they are on eBay for over $60 — too much for hobbyists and too pricey for high school students. Plus, they're difficult to obtain. I put on my thinking cap and went back to the old pendulum method — one of the methods still being used for seismology. The word pendulum comes from the Latin word *pendulus*, meaning 'hanging.'

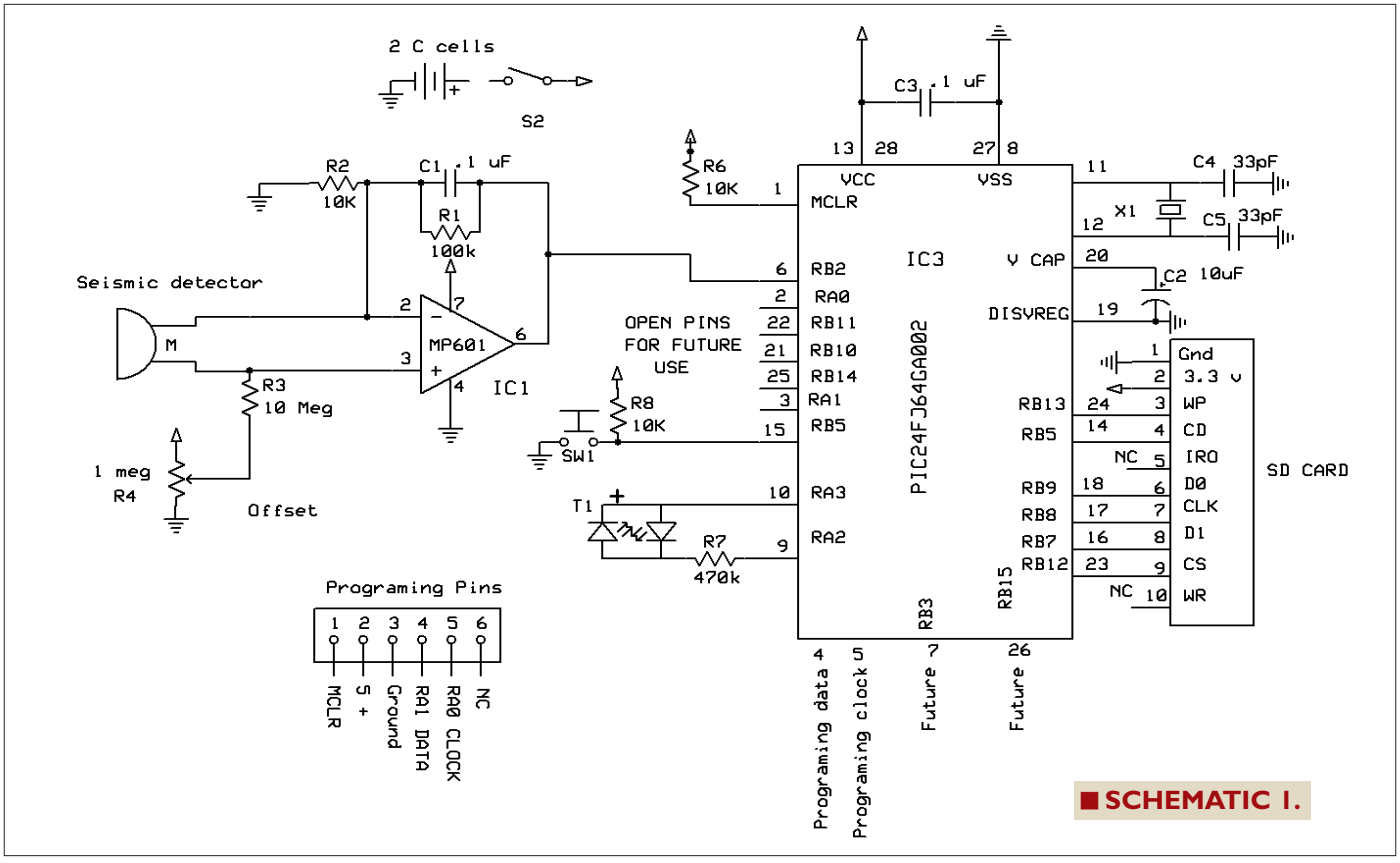
The period of the pendulum is determined by the length of its swing (not its weight) and is given by the formula of $T \approx 2 * \pi * \sqrt{L/g}$ where T is in seconds, L is in meters, and g is the acceleration of gravity. I decided to use a pendulum with a length of 9.8" (.249 meters) to give a period of one second.

$$1\ \text{sec} \approx 6.28 * \sqrt{\frac{.249\ \textit{meters}}{9.8\ \textit{meters/second}\text{^}2}}$$

However, the weight of the pendulum does have purpose as it has to keep the bottom of the pendulum steady while the seismic activity moves the top end of it.

The sensor used is a piezoelectric film that generates a small voltage when bent. The brass bar adds the mass, and the piezo sensor acts as a damper. The voltage from the sensor is amplified by an operational amplifier that feeds into a microprocessor (see **Figure 2**).

When starting a project, I always list the initial



■ SCHEMATIC 1.

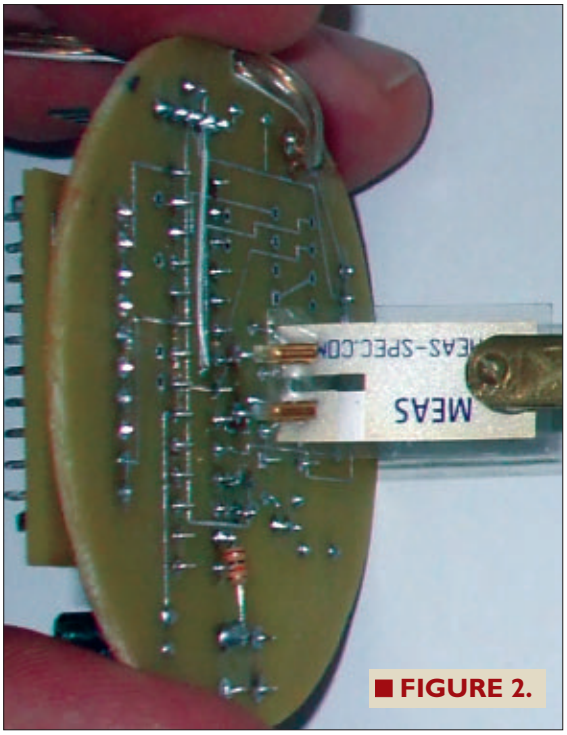
specifications I want to accomplish (which are subject to change, of course). For this project, here's what I started with:

- Inexpensive
- Portable
- Waterproof
- Battery-operated with a battery life of one year
- Indicator when seismic action has taken place
- Data to be removed and downloaded into a computer
- Cost of building the instrument be below $35

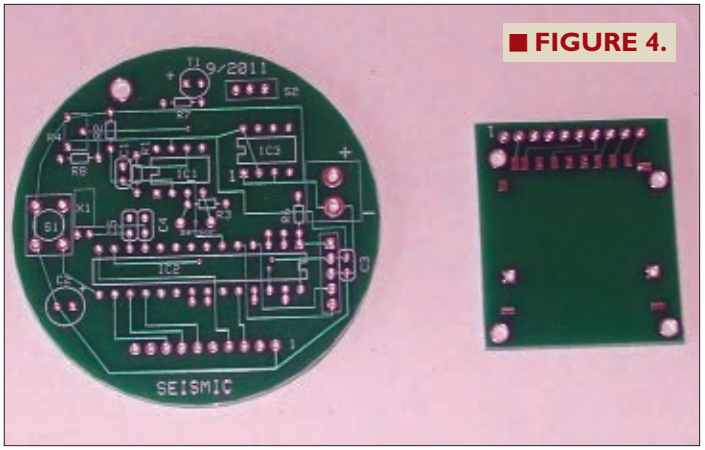
The container for the seismograph is made out of a 13.5″ 3″ OD PVC tube with either an end cap on the bottom or a stand using a 3″ flange (**Figure 3**). A piece of Plexiglas on the top is used for viewing the LED to see if seismic action has taken place.

I ended up using two C cells for the power supply. It was determined that the unit draws 1.5 mA when in standby, and the C cells provide six months of service. The series J microprocessors draws less than .1 µA when in standby. However, when the comparator is used, it draws power along with the op-amp which increases its standby power. The Smart Card

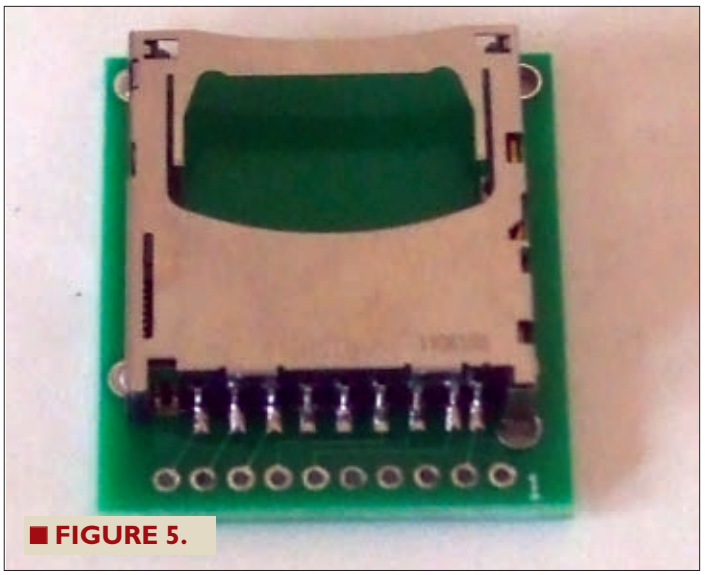
■ FIGURE 3.



■ FIGURE 2.



■ FIGURE 4.



■ FIGURE 5.

memory chip takes most of the power. The C cells sit in the bottom of the PVC tube.

The seismic detector is made out of a Measurement Specialties piezo film vibration monitor. As the piezo film is displaced from the mechanical neutral axis, bending creates very high strain with the piezopolmer and therefore, high voltages are generated. A piece of brass bar measuring 9.8 inches is included to add mass using a #1 screw and nut. This bar acts as a pendulum. The sensor provides about one second of damping.

Electronics

The piezo film sensor generates a small amount of voltage when bent or stressed. This voltage is amplified by the use of a FET non-inverting operational amplifier. The amplifier in this configuration gives a very high impedance input. A Microchip MCP 601 was used, since it can be run using a single voltage supply. The voltage is injected in the non-inverting port configured as an adder, summing a voltage provided by the voltage divider potentiometer R4. This voltage is amplified by 11 times with resistors R1 and R2. The amplification of a non-inverting op-amp is:

$$amplification = 1 + \frac{feedback\ resistor}{grounding\ resistor} \qquad 11 = 1 + \frac{100k}{10k}$$

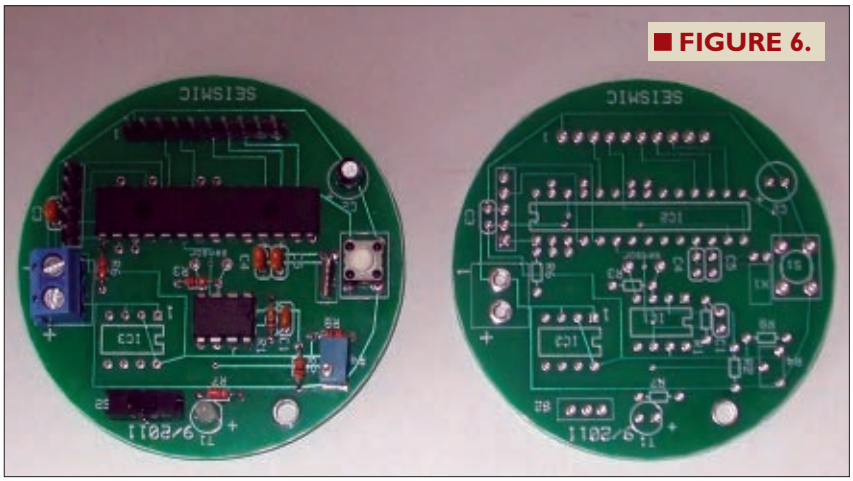
The vibration waves fluctuate above and below a 1.6 volt offset provided by R4. A 10 megohms resistor prevents offset loading to the transducer. The offset allows ± voltages of the sensor to be viewed on a chart without using ± power supplies. The micro measures the voltage 120 times per second.

The bi-colored LED is turned on/off and changes its color by applying opposing voltages to its leads. The LED can generate three colors: red, green, and yellow. It can also be made to flash.

The microprocessor takes the amplified voltage and is channeled to the micro's comparator which continues to run when the micro is put to sleep. Thus, the micro draws very little power. When the voltage of the sensor is compared against a 1.6 volt voltage reference and is exceeded, the micro switches from a comparator mode to an analog-to-digital converter mode measuring the voltage digitally.

The micro opens the first text file on the SD card that is named Seismic1.txt. It then will record one minute of data and then flash the LED every four seconds, indicating that a seismic event has taken place. It then waits for another earthquake and the process starts over again. However, the text file is incremented to Seismic2.txt and will continue endlessly. The unit can be downloaded at any time by turning off the power switch. The SD card is then removed and placed into a computer for downloading and viewing.

A Microchip PIC24FJ64GA002 was used for this project since there is plenty of documentation on how to interface with SD cards. (See the October '10 issue for the "Implementing a File I/O for the 16-bit Micro Experimenter" article by Thomas Kibalo.)



■ FIGURE 6.

Constructing the Board

There are two boards for this project. The first one is for the SD card (**Figure 4**). Turn the board over and solder the six 10K 805 surface-mount pull-up resistors. (Refer again to **Figure 1**.) The best way to do this is to melt a small amount of solder to the top

six pads. Using tweezers to hold the 805, touch the tip of the soldering iron to the pad and place the 805 on it, allowing the solder to flow to the resistor. Do this for the rest of the resistors. Now, solder the other side of the resistor to the pads. Make sure you use rosin core solder. I normally use .6 mm diameter. Turn the board over and solder the SD holder to the top side. Solder each of the pins and ears in their respective holes (**Figure 5**).

The second board will need to be trimmed to the outside circle. The easiest way is to use a sander. Make sure it will slip into the 3″ PVC pipe so you don't have to sand after the components are placed on the board. All the components are placed on the top of the board with the exception of the sensor.

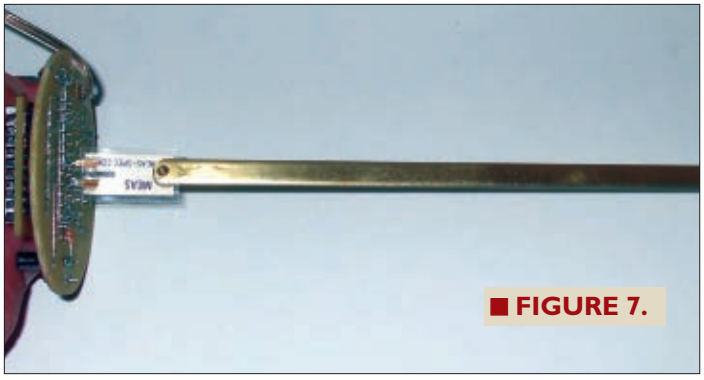
Solder IC1 and IC2 to the board. Note the square hole is pin 1 of the chips. Place the chip in front of you with its notch pointing left. Pin 1 is the lower left pin. Often, there is a small dimple above it. Watch IC2 as pin 1 is the reverse of IC1. Solder the one meg pot, resistors, capacitors, and the crystal. Note the polarity of the 10 µF cap. Solder the two switches.

Solder the LED with its long lead going to the square pad. Cut two headers: one with 10 pins and the other with five pins. Solder them to the board. There will be extra pads next to the microprocessor that can be used for other projects. **Nothing will go in IC3 as this is for a future project.** There will also be empty pads for those who may want to add alarms or other items (**Figure 6**).

Take the SD circuit board and place it over the 10-pin header. It should rest on the micro. Solder the 10 headers.

Cut the 1/4″ x 1/16″ brass bar to nine inches. Drill a 1/16″ hole 1/8″ from one end of the brass bar. Use a #0-80 3/8″ screw and nut, and fasten it to the piezo sensor. Add a drop of fingernail polish to the nut. Solder this assembly to the bottom of the board (**Figure 7**).

Solder two 13″ wires to the battery holder. Make sure you can identify the positive wire. The programming was written in C. The square pad is pin 1 for the programmer. There are only five pins needed (the sixth is redundant).


■ FIGURE 7.

Container

There are two types of containers that you can use for this project. One is waterproof for placing in the ground; the other is a stand-alone unit which can be mounted on the floor.

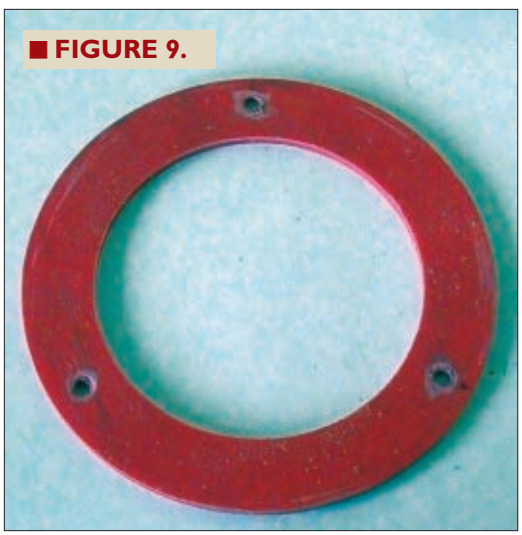
The container is made out of a 13.5″ piece of 3″ PVC pipe plus a 3″ flange for stand-alone applications or an end cap for burying. The top of the pipe should be smooth. The PVC pipe will be loose in the flange. With a lathe, I turned 1/2 of a 3″ collar to fit the flange. Another way is to use duct tape and build up the pipe to fit the flange.

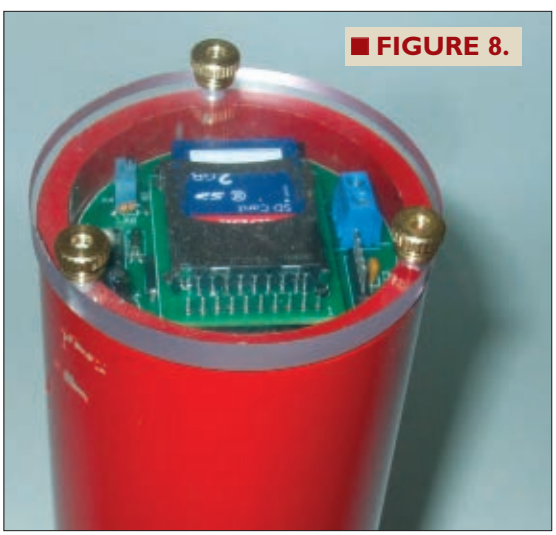
Go to the *Nuts & Volts* website and download the files which go with this project. There you will find a template for the Plexiglas lens. Cut out and then glue a 1/4″ piece of Plexiglas to it. Sand the Plexiglas to the edge of the circle. Using a 9/64 drill, drill three holes. Remove the template using hot water. Place the lens over the smoothed end of the PVC pipe. Mark the pipe where the holes are.

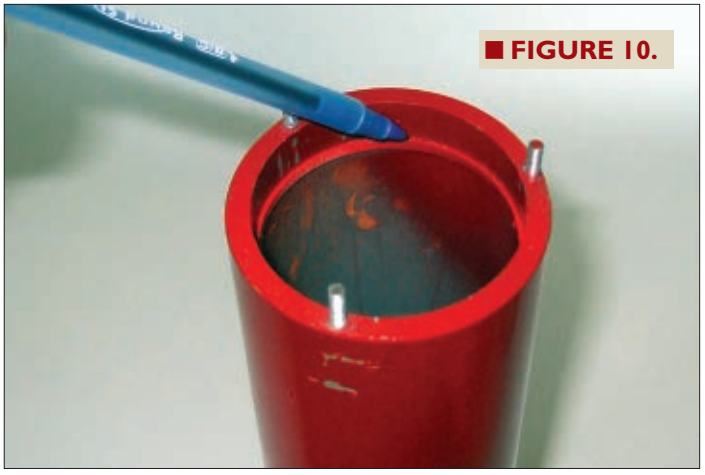
Using a #36 drill, make the three holes 1/2″ deep. Tap each hole with a 6-32 tap. Using three 1″ screws, add a drop of super glue to each hole and fasten each screw into the PVC pipe. Use a cut-off tool and remove the heads. If implementing a flange and not a cap, use the bottom template to cover the bottom. Glue this piece to the bottom (**Figure 8**).

Whether you use the seismograph inside or outside, you will need the lens to protect against air movements. If you are using the unit outside and it needs to be waterproof, buy a 3″ flush valve washer. Using the lens, mark the gasket and punch three holes (**Figure 9**). Place the gasket over the screws. If done properly, the lens should fit over the screws and then can be secured by three knurled nuts.

Cut a piece of .06″ x .125″ Styrene plastic strip to 7.75 inches. Bend the strip and place it 5/8″ from the edge of the PVC pipe. Using super glue, attach the strip in


■ FIGURE 9.


■ FIGURE 8.



■ FIGURE 10.

place. This will act as a support for the board (**Figure 10**). If using an end cap, place the PVC pipe into a bucket or a coffee can to keep it vertical. Load the battery holder with two C batteries and slide it into the bottom of the PVC pipe. Use small pieces of tape to hold the wires to prevent them from hitting the pendulum. Slide the board and its pendulum into the tube, and feed the two wires though the hole next to the pot (**Figure 11**). Try not to let them short. Allow the board to sit on its support. Place the two wires in their respective terminals and tighten. You might want to mark the positive terminal with a drop of red fingernail polish. **DON'T REVERSE THE LEADS!**

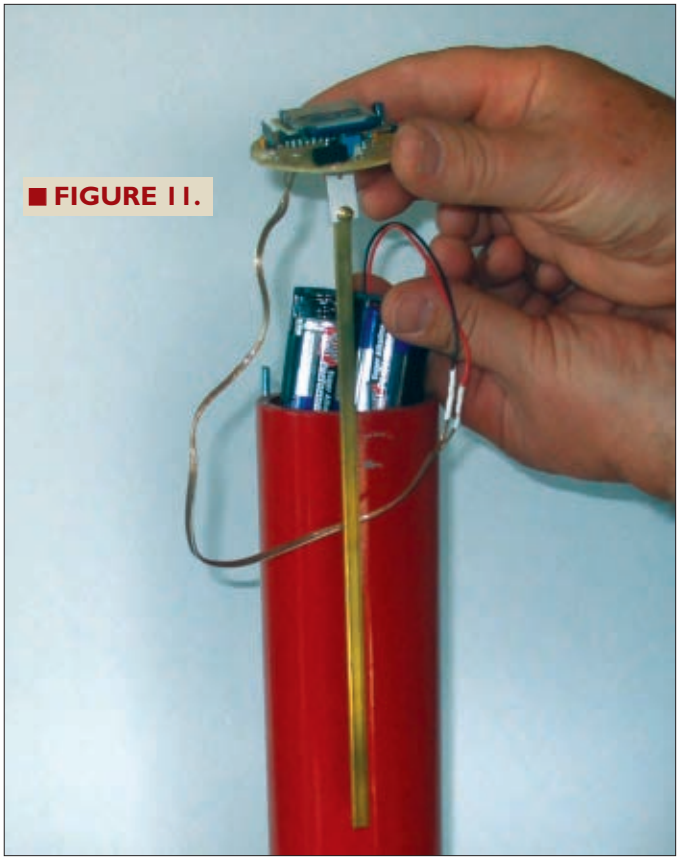
Turn on the power switch. The LED should turn red, indicating that power is being supplied. Turn the unit off. Hold the red switch down and turn on the unit. This will place it in the calibration mode. Release the red switch. If the LED is red, turn the pot clockwise until it turns yellow-orange. If the LED is green, turn the pot counter-clockwise until it turns yellow-orange. Set the pot when the LED just turns red. This sets the trip point. Turn off the unit. If the unit is too sensitive, turn the pot counter-clockwise an 1/8 of a turn.

Using the Unit

Using your computer, format an SD card from 256 MB up to 2.0 GB. **NOTE: If you have a computer that does not have an SD card port but you do have USB, there are adapters available**. A seismic recording only takes up 35.1 kb. That's a lot of earthquake recordings! Now, we are going to set the time in the microprocessor's clock. **NOTE: If the power is turned off, the micro's clock will be lost.** Download the Excel sheet titled "Time Calculations for Seismic" from the article link. Follow the directions on the spreadsheet. The time is written to the SD card using a BCD format in hexadecimal code. The time.txt file contains six bytes of code for programming the Smart Card. Make sure you allow enough time to place the card into the unit.

Load the card. Turn on the unit. The LED should be red. Watch the clock and when it reaches the proper minute, press switch 1 and release. The LED should flash green indicating that the micro's clock has been set to the time you programmed on the SD card.

Once you have decided where you are going to place the seismograph, you can activate it by pushing the switch. The LED will turn on steady red for one minute. This will allow you to place the lens on and secure it with



■ FIGURE 11.

PARTS LIST

ITEM	DESCRIPTION	QTY	SOURCE
C1	100 pF 100V ceramic	1 ea	
C2	10 µF 16V aluminum	1 ea	
C3	.1 µF 100V ceramic	1 ea	
C4-C5	33 pF 100V ceramic	2 ea	
Header	.025 square pin .1	15 ea	
IC1	MCP601	1 ea	Microchip
IC2	PIC24FJ64GA002	1 ea	Microchip
R1	100K 1/6 watt	1 ea	
R2-R6-R8	10K 1/6 watt	3 ea	
R3	10 meg 1/6 watt	1 ea	
R4	Trimmer 1M .25 watt	1 ea	
R7	330 ohms 1/6 watt	1 ea	
R9-15	10K 805	6 ea	
S1	Momentary red	1 ea	
S2	On/off slide	1 ea	
SD Holder	SD/IO	1 ea	
Sensor	Piezo film vibra mass	1 ea	Measurement Specialties /Schaevitz
T1	Bi-colored LED	1 ea	
X1	Crystal 32.768 kHz 6PF	1 ea	
HARDWARE			
Battery holder two C		1 ea	
Brass bar .25" x 1/16"		1 ea	
.06 x .125 Styrene strip 7.75"		1 ea	
3" OD PVC pipe 13.5"		1 ea	
PVC end cap or 3" flange		1 ea	
#0-80 3/8" brass screw and nut		1 ea	
6-32 1" screws		3 ea	
6-32 brass knurled nuts		3 ea	
3.5" x 3.5" 1/4" Plexiglas		2 ea	
3" Flush valve washer		1 ea	
13" #24 wire		2 ea	

the knurled nuts. When the red LED goes out, it indicates that it is armed.

When the unit is jarred or an earthquake happens, the data will be written to the SD card and the LED will turn a yellow–orange indicating that it is making a measurement. Once the unit has made a one minute measurement, the LED will flash red about every four seconds, indicating that an earthquake has occurred.

When you are ready to read the data, remove the lens (this will activate the unit and record the jarring of the removal but it will end up as an invalid txt file). Turn off the power and remove the SD chip.

Viewing the Data

To view the data, go to **www.dataq.com** and download their free software under the downloads titled "WinDaq Waveform Browser." For those of you who are interested in great data loggers and data acquisition, I can't say enough good things about WinDaq. The browser is also located on the *N&V* website.

Once the Waveform browser is downloaded, there should be an icon on your computer. Click it. A window should open up. Locate the SD card and make sure you have "Files of type" on "(*.txt)" — look for the "Seismic1.txt" file or other numbered seismic files. Click on this. Perform a save on Seismic1.wdc (default). Use #2 "Spreadsheet print file (ASCII)."

The convert screen should pop up and default on "volts." Hit the return key. (This is subject to change, depending on what version you have with your browser.)

The Waveform browser should now be visible. If you go to "options" and click on "Cursor time," the date and time of the earthquake will show at the bottom. Moving the cursor below the red line will show the time. By pressing F4 to place a time marker, you can measure from the time marker the seconds from an event.

There is a plethora of commands you can use in the WinDaq browser, and I defer you to their help menu, since it would take a small book to explain them all. Once you have the screen up, you can calculate the "S" and "P" waves and their times to determine how far away the epicenter was located. Keep in mind that it takes at least three seismographs to locate the epicenter with triangulation. Once you have downloaded your data, delete all the seismic.txt files on the SD card to re-record.

Now, we just have to wait to shake, rattle, and roll! **NV**

The boards and preprogrammed chips are available at the *Nuts & Volts* webstore. If you wish to have your own boards made, I have included the Express PCB board files and the Microchip ASM files, along with Hints and Tips at the article link. Always check to see if there are any updates in Hints and Tips before building.

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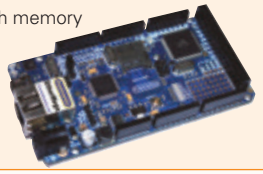

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- 8 analog inputs
- MicroSD memory card slot

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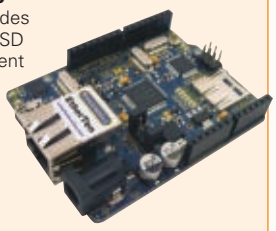

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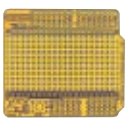

- Gold-plated surface

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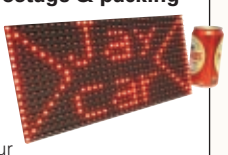
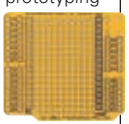


- 32(L) x 16(W)mm high brightness Red LEDs (512 LEDs total) on a 10mm pitch
- 5V operation
- Viewable over 12 metres away
- Tough plastic frame
- Controller IC's on board, simple clocked data interface
- Arduino compatible library, graphics functions and example support

ProtoShield Short

XC-4248 $3.75 plus postage & packing

A dedicated short version prototyping shield for EtherTen and EtherMega. This special prototyping shield is designed to fit neatly behind the RJ45 Ethernet jack, allowing you to stack your Ethernet-based projects right on top with standard headers.

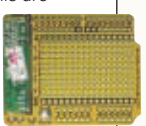


- Pads available to fit a reset button
- Gold-plated surface for maximum durability

Receiver Shield 433MHz

XC-4220 $21.75 plus postage & packing

This receiver shield lets you intercept 433MHz OOK/ASK signals, decoding them in software on your Arduino. All the Arduino headers are broken out to solder pads, and GND and 5V rails are provided for convenience.



- Reset button
- Blue "power" LED
- Red and green user-defined LEDs
- Gold-plated surface
- 433MHz tuned frequency

LCD & Keypad Shield

XC-4218 $21.75 plus postage & packing

Handy 16-character by 2-line display ready to plug straight in to your Arduino, with a software-controllable backlight and 5 buttons for user input. The display is set behind the shield for a low profile appearance and it includes panel mounting screw holes in the corners.

- 2 rows of 16 characters
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- Software-controlled backlight
- Reset button
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BUILD A SOUND-ACTIVATED LASER PARKING SYSTEM

By Paulo Oliveira

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

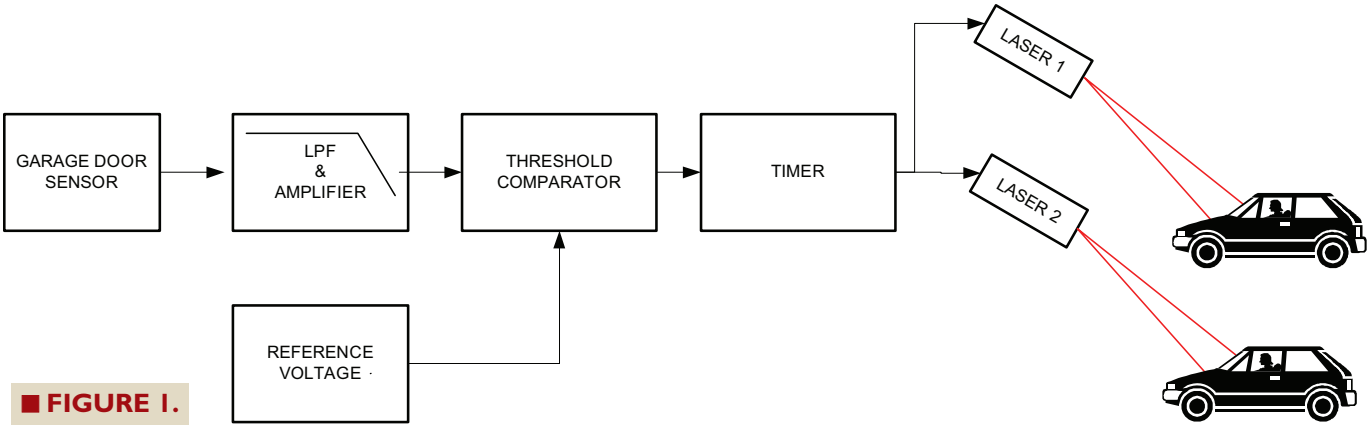
Many methods to assist the "parking challenged" — a group the author proudly belongs to — have been developed over the years. These methods range from the prosaic "hanging tennis ball" to more sophisticated ultrasound-based proximity detectors. In this article, we show an approach built around two ordinary low power laser pointers repurposed as parking assist beams. The lasers in this project are activated by the sound generated while the garage door is opening.

Overview

Figure 1 shows the block diagram for this project. The garage door sensor detects when the garage is opened (or closed). Perhaps the simplest way to implement such a detector would be to use a simple mechanical limit switch or even a magnetic switch coupled to the garage door rails. Another option is to use a signal derived from the garage opener box such as a light sensor (most garage door openers turn a lamp ON while opening the garage door). In this project, we opted for a sound detector. While this type of detector might not be the simplest, it has the advantage that it requires no extra wiring towards the garage door. Furthermore, because this sound detector has no moving parts, it can be expected to be more reliable than solutions built around mechanical switches. It is also much more fun to build!

One obvious disadvantage is that the sound trigger is not only activated when the garage opens, but also when it closes. This is not an issue, though, as the laser beams can be ignored if not needed.

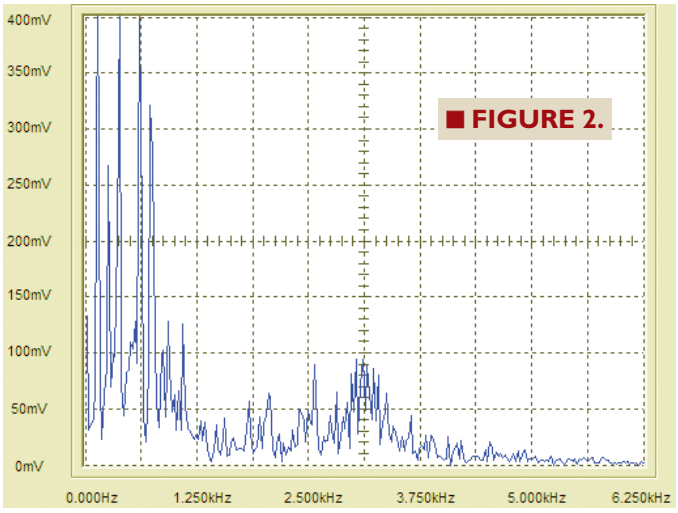
The signal from the garage door sensor — in this case, the output from an electret microphone — is amplified and low-pass filtered before driving a threshold comparator. Recording the sound produced by the garage door opener when in use and then running it through audio FFT spectrum analysis software resulted in the plot in **Figure 2** (x axis is frequency while y axis is amplitude). The plot



■ FIGURE 1.

shows that the sound generated by the garage opener (recorded also with an electret microphone) contains mostly low frequency components, roughly below 1 kHz.

Filtering the high frequency components from this signal reduces the occurrence of false triggering events (think of listening to music while working in the garage). The filtered and amplified signal is then applied to one of the inputs of a threshold comparator whose second input is tied to an adjustable reference voltage. This adjustable reference voltage effectively controls the sensitivity of the device. The output of the comparator triggers a simple timer circuit that turns the two laser modules on for a period of about one and a half minutes. The laser modules are made of inexpensive low power laser pointers that were modified to generate a line (instead of a dot) using a homemade cylindrical lens (more on this later). The line generated by the lasers can then be used as a parking reference by the car driver.

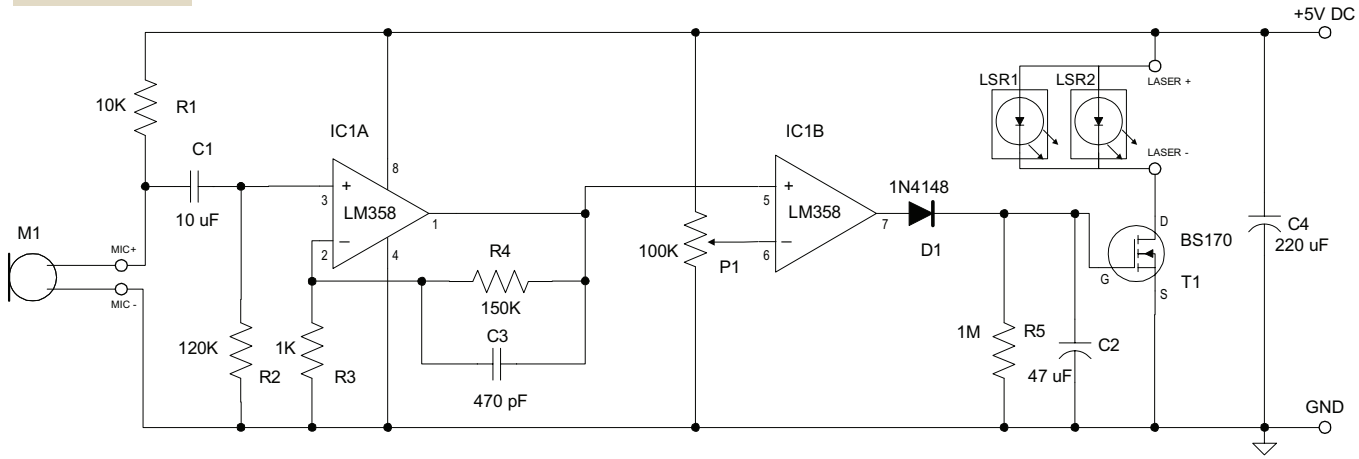


■ FIGURE 2.

Circuit Schematic

Figure 3 shows the circuit schematic. The sound sensor is built around a common electret condenser microphone M1. The resulting signal is applied to the first stage of an LM358 dual op-amp. IC1A is configured as a non-inverting amplifier with a gain of 151. If more gain (increased sensitivity) is required, the value of R4 can be increased according to the formula Av = 1 + R4/R3. Capacitor C3 in parallel with R4 limits the gain at high

■ FIGURE 3.

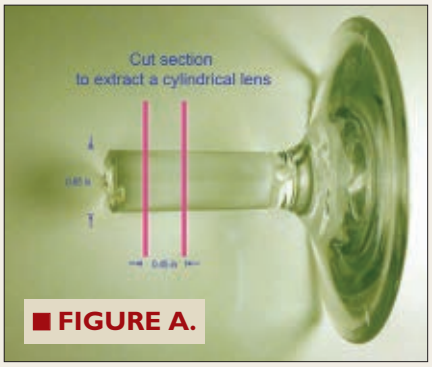


DOT LASERS VERSUS LINE LASERS

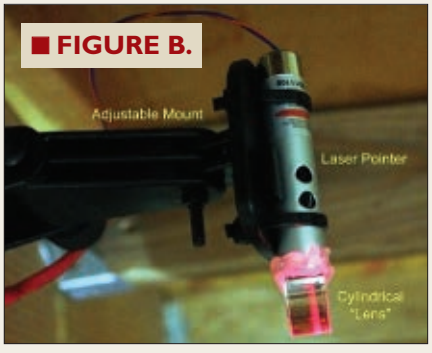
Though it is possible to purchase laser modules that project a line instead of a dot, I found some of these modules project a very dim line. In particular, modules with a wide "fan angle" distribute the laser power over a long line which can greatly reduce the visibility. Considering that the car windshield reflects some of the incident light, this can result in a rather weak, hardly visible line projected on the car dashboard. If you plan to use a line laser, consider one with a narrow fan angle, such as 20 degrees.

Dot lasers are easier to find and are typically less expensive than narrow angle line lasers. Therefore, the solution adopted in this project was to use a cylindrical lens glued on top of a standard dot laser pointer. The lens produces a short (but strong) line that can be easily seen inside the car.

There are several ways to build a cylindrical lens to turn a dot laser into a line laser. The method used for this project was to cut a small section out of a plastic glass stem (see **Figure A**) using a hack saw. No polishing is required since the surface of the stem is the polished part of the lens, and is usually already smooth. The result is shown in **Figure B** in more detail. I also experimented with different glass stems and you can certainly use different sizes. The size of the lens will affect the length of the line. Some experimentation may be needed depending on the distance from the laser to the dashboard.



■ FIGURE A.



■ FIGURE B.

frequencies. The gain-bandwidth product of the LM358 further limits the overall high frequency response of this stage so that frequencies above approximately 2 kHz are not amplified. IC1B works as a threshold comparator whose output is high whenever the output from IC1A exceeds the voltage set by the P1 trimpot configured as a resistive divider. P1 should be adjusted to select the adequate sensitivity while avoiding false triggering events.

When the IC1B comparator output is high, capacitor C2 charges very quickly through diode D1. When the voltage across C2 exceeds the threshold voltage of the BS170 N-channel MOSFET, T1 turns on and activates the low power laser modules LSR1 and LSR2. The lasers remain on as C2 slowly discharges through the 1M resistor R5 until the C2 voltage drops below T1's gate threshold voltage. D1 blocks the low impedance path towards ICI1B's output. Since the gate of T1 is

PARTS LIST

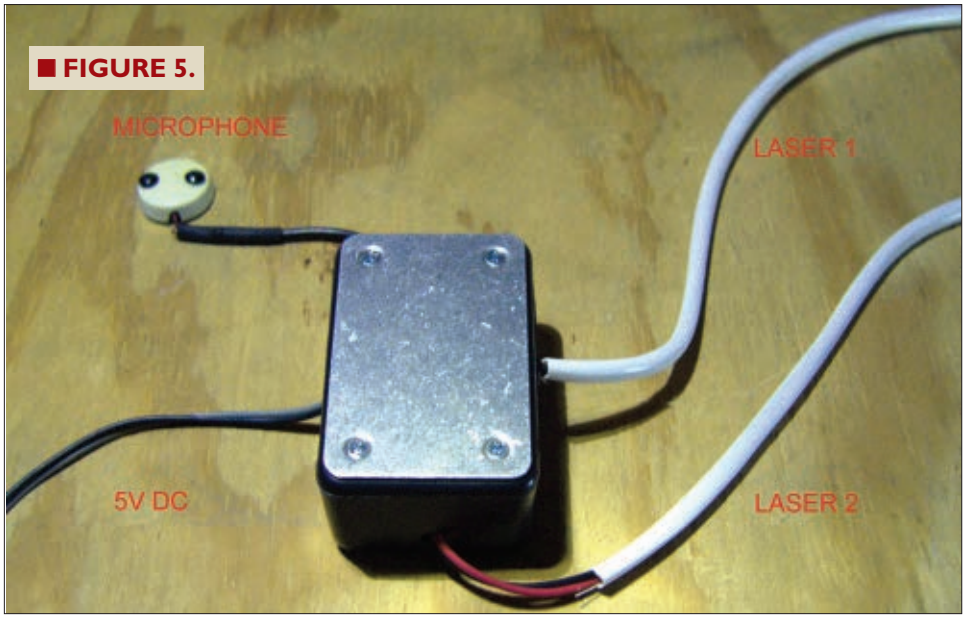
ITEM	DESCRIPTION	SOURCE
Active Components		
IC1	LM358 Dual op-amp	Digi-Key LM358ANNS-ND
T1	BS170 N-channel MOSFET	Digi-Key BS170_D26ZCT-ND
D1	1N4148 Small signal diode	Digi-Key 1N4148TACT-ND
M1	Electret microphone CMA-6542TF-K or equivalent	Digi-Key 102-1719-ND
LSR1, LSR2	Low power (< 5 mW) laser pointers (modified; see text)	Amazon **http://tinyurl.com/6wohh6c**
Resistors	All 1/4W 5% axial carbon film	
R1	10K	
R2	120K	
R3	1K	
R4	150K	
R5	1M	
Capacitors		
C1	10 µF, 10V tantalum	
C2	47 µF, 10V tantalum	
C3	470 pF, ceramic	
C4	220 µF, 10V tantalum or electrolytic	
Miscellaneous		
Project case	RadioShack (3x2x1") project enclosure	RadioShack Model 270-1801
Power supply	5V AC adapter (0.4A or higher)	
PCB	perf-board	
Cable	18 AWG Speaker cable or similar	

essentially an open circuit from a DC standpoint (leakage currents aside) and D1 is reverse biased, the time constant for the C2 discharge is primarily determined by the values of R5 and C2.

With the values shown in **Figure 3**, the lasers remain on for approximately one and a half minutes. This time period can be increased (or decreased) by adjusting the values of R5 or C2. Note that this is not a particularly accurate timing mechanism. The actual on time varies significantly with ambient temperature. However, this is not of much consequence for the application at hand, since it does not require precise timing; just enough time to park the car in the garage.

The circuit is supplied from an external 5V AC-DC regulated adapter decoupled by capacitor C4. The low power (less than 5 mW) laser pointers used in this project work nominally at 4.5V (three 1.5V button cells) which is close to the 5V supply minus the voltage drop across the BS170 drain-to-source on resistance. The project consumes less than 5 mA in standby and roughly 120 mA when both lasers are on (the on current depends mostly on the laser module's drive requirements).

■ **FIGURE 4.**



■ **FIGURE 5.**

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■ FIGURE 6.

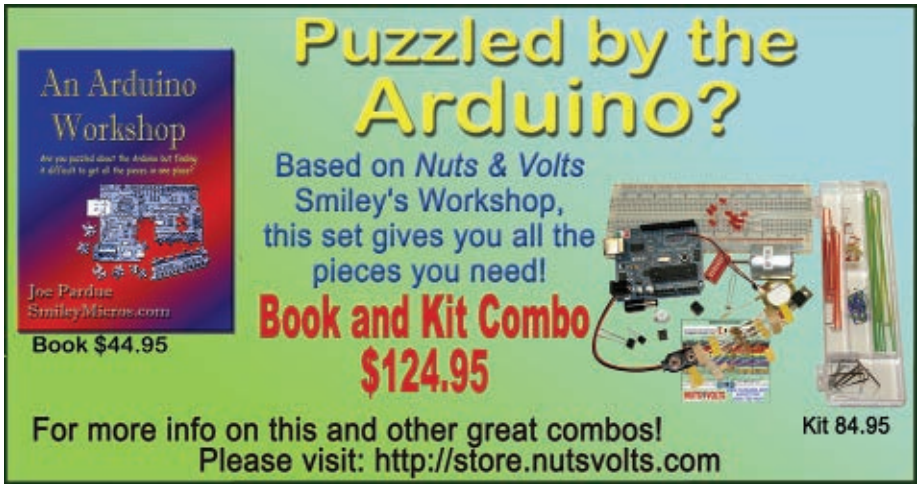
Assembly

The circuit is simple enough to build using a standard perf-board and plastic enclosure as shown in **Figure 4**.

To improve the microphone's sensitivity, the electret microphone was directly coupled to the wood structure in the garage as shown in **Figure 5**. The microphone is enclosed in a plastic bottle cap and mounted with two wood screws. This mounting strategy minimizes the sensitivity to noise generated by sources other than the garage opener motor. **Figure 5** also shows the connections to the two laser modules and the 5V power supply input wiring. Standard 18 AWG speaker wire was used for the connections.

As mentioned earlier, the lasers used in this project were obtained from repurposed low power laser pointers. The first step in adapting the laser pointers is to permanently bypass the on pushbutton. After extracting the three 1.5V button cells, solder wires to the positive and negative supply terminals and connect them to the controller box. The procedure might be slightly different depending on the actual laser used.

Figure 6 shows the final laser assembly installed on an adjustable mount. In this case the adjustable mount was obtained from an unused GPS dashboard car mount.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After installing the system components, adjust the threshold voltage with P1 until the sound from the garage opener triggers the lasers reliably. Park the car in the garage in the desired position and point the laser to a reference point in the dashboard surface that can be used to guide your parking. **Figure 7** shows an example using a narrow band of plastic in the dashboard as a reference point.

■ **FIGURE 7.**

Final Points

This was a very fun project to build and it has greatly improved my parking accuracy. With this system, it's easy to achieve accurate parking every time. **Caution**: Here are some safety recommendations when using lasers:

- Avoid direct eye exposure to the laser beam as this can cause eye damage. Do not stare into the beam.
- Use only low power lasers (5 mW or lower).
- Orient the laser so that it points to the dashboard but doesn't point towards the driver directly (see **Figure 7**). Ensure the laser light doesn't reflect towards the driver.
- Don't allow unsupervised children or pets to be exposed to the laser beam when in the garage. Turn the system off when in doubt by unplugging the AC adapter or installing a power switch. **NV**

ELECTRONIC SCHEMATIC DIAGRAMS FOR EXPERIMENTERS AND TECHNICIANS

By David Herres

Electronic schematic diagrams with huge repertoires of wonderfully intuitive symbols are excellent media for communicating design ideas and laying out projects prior to breadboard or solder prototypes. We've all sketched out schematics on paper, then attempted to create finished products using drafting tools and mylar. Usually, the end result is acceptable for shop work or personal archives, but lacks the polished perfection one would desire for a Power Point presentation or graphic to accompany published text in print or on the Web.

A large number of computer programs exist that are able to create flawless schematics on a drag-and-drop or command line basis, but there is a definite learning curve involved — quite daunting in the majority of cases. As would be expected, an application's difficulty is in proportion to its functionality. Specifically, the more it can do, the harder it is to comprehend. We'll take a detailed look at both ends of the spectrum, in hopes of finding the right application for the usage that is contemplated.

1. WHAT'S AVAILABLE?

To begin, a few observations are in order:

• Prices for these programs vary from many thousands of dollars to free, depending on the features that are desired. We'll focus on the free end because even for the serious experimenter, it may not be appropriate to invest heavily just as an idea is born.

• There are plenty of cross-platform applications out there, but those in an early or arrested stage of development may be for PC only, so if you are working on a Mac, keep that in mind.

• Before downloading, check out the operating system requirements. If your machine doesn't qualify, don't pursue the matter because it won't work. For older machines, there are plenty of backward compatible programs available.

• Besides schematic capture, some related operating models are part of the scenario and these, in some cases, are available as a suite of applications.

First, we need to look at SPICE. This alluring acronym is derived from Simulation Program with Integrated Circuit Emphasis. It was conceived at the University of California at Berkeley in the 1970s, and over the years enhancements have been added that greatly increase its usefulness. The rationale — at first — was to enable testing

and adding modifications to circuit designs without requiring actual fabrication. (Integrated circuits — relatively new at the time — are way too expensive to prototype on a speculative basis). What SPICE does is simulate electronic circuits which you enter on your computer. At that point, it is possible to examine and record circuit parameters including voltage and waveforms extracted at various locations, just as if you had built the hardware version, connected a signal generator and oscilloscope, and run a test drive. This program wrote the book on *virtual*.

The key concept for starting up a SPICE simulation is the netlist. From the circuit schematic, a text file is created containing a list of components and the nodes — called nets — which connect them. The procedure is to name a component, designate connecting nodes, and assign values to them.

Needless to say, it is necessary to conform strictly to certain conventions, and everything has to be letter perfect. Resistors, for example, are named R, followed by the numbered nodes to which they are connected and the value in ohms. Also, a voltage source (designated VS) is specified.

Since SPICE is open source, researchers and commercial entities have been free to add schematic capture front ends and graphic interfaces after the main event to facilitate understanding circuit behavior. SPICE is available from a number of vendors with widely varying appearances, enhancements, and degrees of complexity.

The other major add-on to the basic schematic capture package involves PCB (printed circuit board) design. Schematic diagrams observe certain conventions which should be adhered to if the goal is communicating the purpose and operation of a contemplated assembly. Power comes in on the left. The signal proceeds through one or more stages to an output device — perhaps a loudspeaker — at the far right. Input signals may begin at the top (an antenna, for example) and any ground connections will be shown at the bottom.

The final PCB — while electrically equivalent to the schematic — has no mandate to embody the same layout. To the contrary, there are definite goals to be achieved in PCB design, having nothing to do with conveying to others the logic of the circuitry. Economy of routing, maintaining separation between traces that carry incompatible signals, and providing correct and uniform characteristic impedances are some of the concerns.

The purpose of an electronic schematic diagram in the early design stage is to organize and aid in conceptualizing the structure that will eventually be built; alternately, the diagram may be intended as an educational tool that will never actually take physical form. Either way, the finished diagram is intended to communicate to others, perhaps so that colleagues can suggest refinements and (eventually) so that a PCB or wired version may be created.

2. SOME CONVENTIONS

As mentioned, the schematic does not depict the final component and wiring layout, which may be quite different. The idea is to display logical relationships rather than the physical reality of the end product. Accordingly, in the interest of clarity, certain conventions have evolved and they should be observed. Wires in a schematic should not cross but proceed in straight, evenly-spaced parallel lines with 90 degree bends as necessary. If wires must cross, they are assumed not to be connected electrically unless there is a distinct spherical dot at the intersection.

Four-way connections should not be used — they make it difficult to follow power and signal flow.

Power and ground interconnections need not be shown in all cases, as all this could make the diagram cluttered and difficult to read. Instead, label grounds and inputs separately throughout the diagram, even if they occur on separate pages. This is called "global annotation."

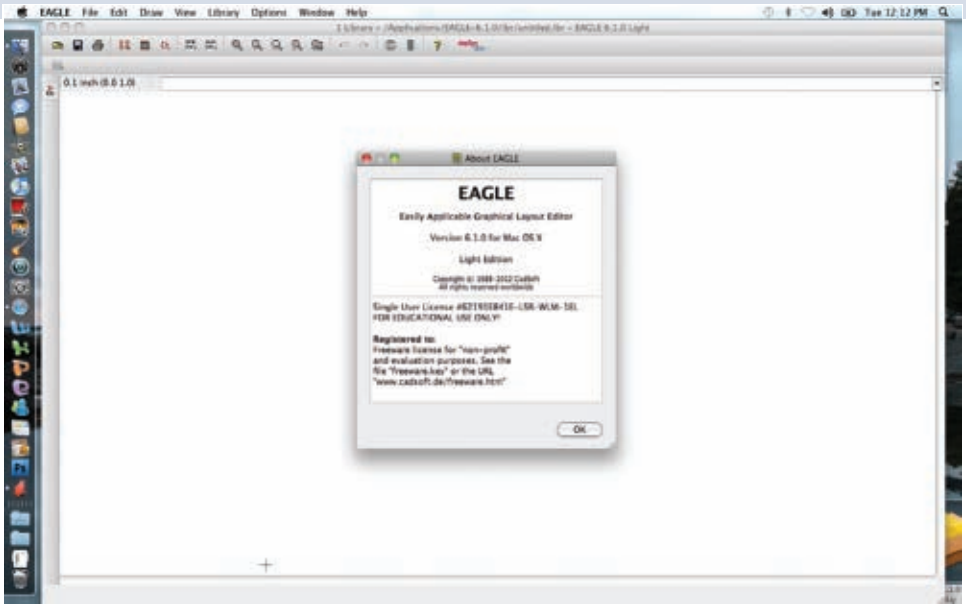
Power and signal flow should be from top to bottom and from left to right. Positive supply voltages should be above ground symbols. Circuits should be developed as functional blocks to facilitate understanding.

In the lower right corner, make a title block. It should contain the title, revision number, date, and other pertinent information. If the overall sheet is large so that it has to be folded for filing, the title block should appear on the outside so that it is visible without unfolding. Circuit symbols should be strictly adhered to. This makes for readability. A frequent add-on to the basic schematic capture package is the PCB design which becomes the output in a variety of ways.

Cadsoft's Eagle PCB design software is the preeminent schematic capture, board layout editor, and autorouter. Eagle is an acronym for Easily Applicable Graphical Layout Editor. Enormously capable and full of advanced features, it is a good choice for the adept technician who is willing to delve deeply and devote lots of time to the endeavor. The good news is that there is a freeware license with modest restrictions, making it a realistic option for the serious experimenter who may not have corporate resources, but makes up for it with significant knowledge and expertise. (See **Figure 1**.)

After creating the schematic, Eagle will create computer files that can be sent to a professional PCB manufacturer. These universal standard files are called "Gerbers" and they contain PCB specifications so that the boards can be manufactured in any quantity.

The Eagle tutorial is not at all sufficient for this highly complex application. If you want to work in Eagle, you will need to acquire the necessary knowledge from various sources. There are third-party tutorials and commentaries,



SCREENSHOT 1. Eagle's Light Edition is free for nonprofit and educational purposes.

and eventually you will prevail. (See **Figure 2**.) The way to edit a schematic is to place a sample in the schematic window. Then, type commands in the space provided to modify the schematic as desired. There are alternate methods:

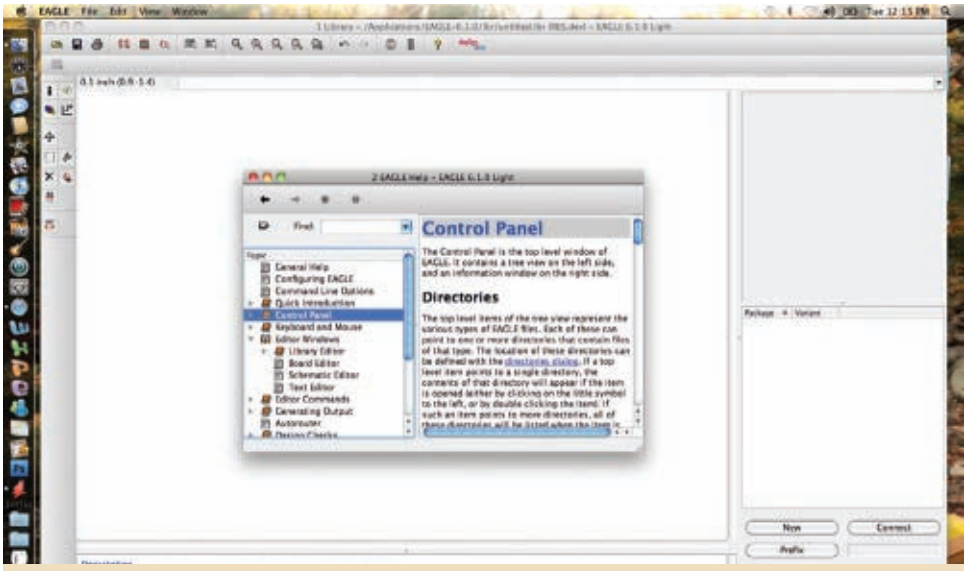
- Select the desired action from a menu.
- Click the toolbar.
- Click the command text.
- Click the command's icon.

To connect a wire, type "wire" in the command space. Just the first three letters (wir) will suffice. Then, in the work space, single click to start the wire and make angle turns. Click on the final destination to terminate the wire. (See **Figure 3**.)

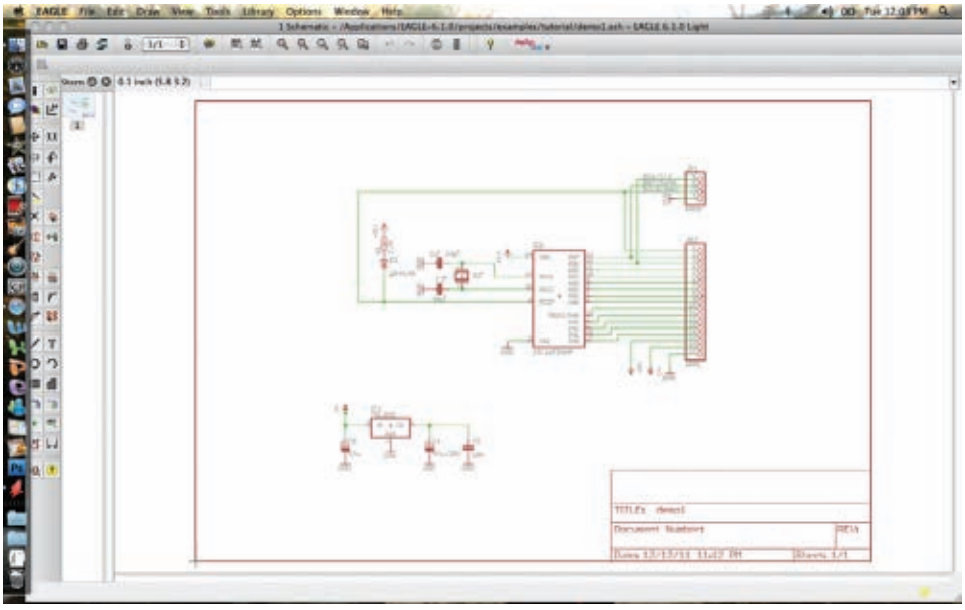
All of this is fairly complex, and it becomes more so as you begin adding components to the library.

You may be saying, "Wait a minute! I'm not a computer programmer. All I want to do is draw precise electronic schematics for personal use or to send to my colleagues, or for publication in print media and on the Web. Circuit simulation and PCB design are not on the agenda at this time." If this is your position, there are simple Web-based applications that will do what you want without requiring hours of preparation.

An intriguing addition to the schematic capture field is Fritzing (**www.fritzing.org**). It is an open source product that is being developed by researchers in the Interaction Design Lab at the University of Applied Sciences, Potsdam, Germany. It provides an education-oriented user experience that includes the ability to document prototypes, share them with others, present electronics courses in a classroom setting and make PCB layouts for

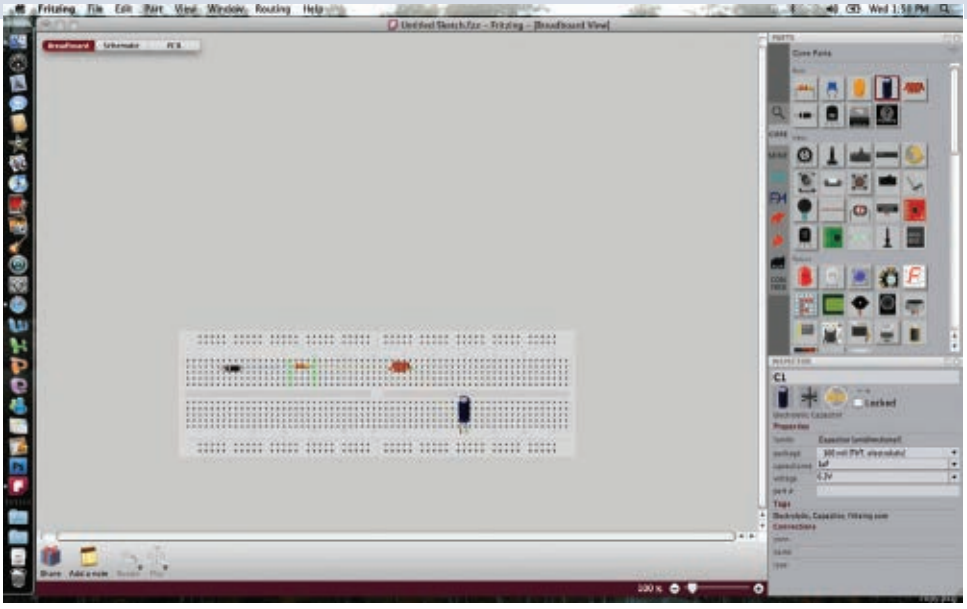


SCREENSHOT 2. Eagle's Help document defines the Control Panel and provides information on directories.



SCREENSHOT 3. An Eagle schematic with the title block.

SCREENSHOT 4. Fritzing's breadboard view.



manufacturing. Three tabs allow the user to switch from breadboard to schematic to PCB views at any stage of the project. Take a look at **Figures 4**, **5**, and **6**. By clicking on File>Order a PCB, you can have Fritzing ship PCBs based on your design from their manufacturer in Germany with no minimum quantity.

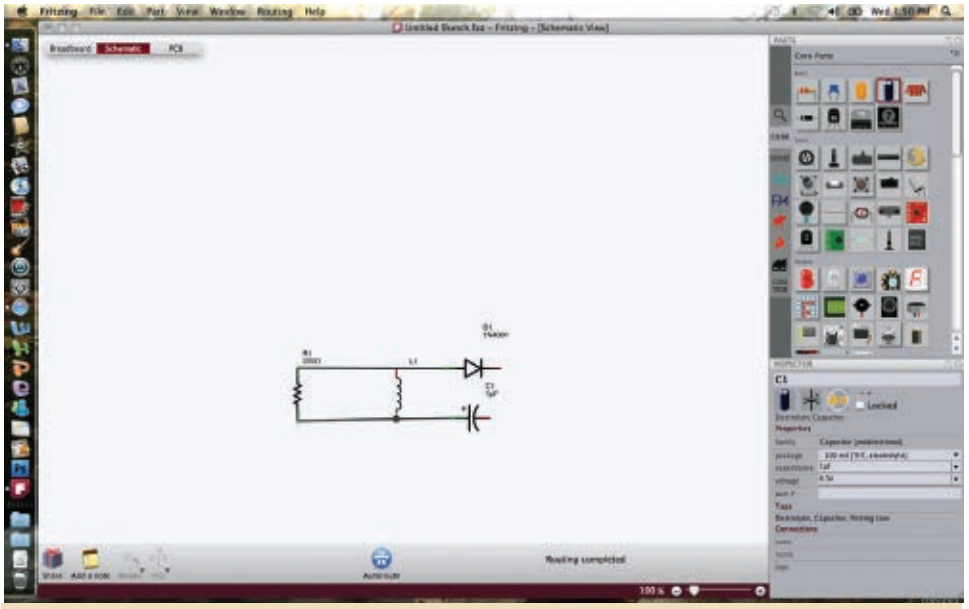
Another prominent player is ExpressPCB (**www.expresspcb.com**). It works in a similar fashion, though it is for Windows only, not Mac. (See **Figure 7**.) The free design software includes two applications: one for drawing schematics, the other for PCB layout. As in Fritzing, PCBs can be ordered through the website. Three 2.5″ x 3.8″ boards will arrive in a few business days for $51 plus shipping. AP Circuits, PCB Pool, Sunstone Circuits, and V-Module are major players, as well.

3. ENTER DIGI-KEY

A newcomer to the field of schematic capture is called Scheme-It — recently released by Digi-Key Corporation. It doesn't engage in circuit simulation or PCB design. The focus is on creating a simple, crisp, highly professional electronic schematic diagram without the bells and whistles in Eagle and without the enormous, arcane features in SPICE. (See **Figure 8**.)

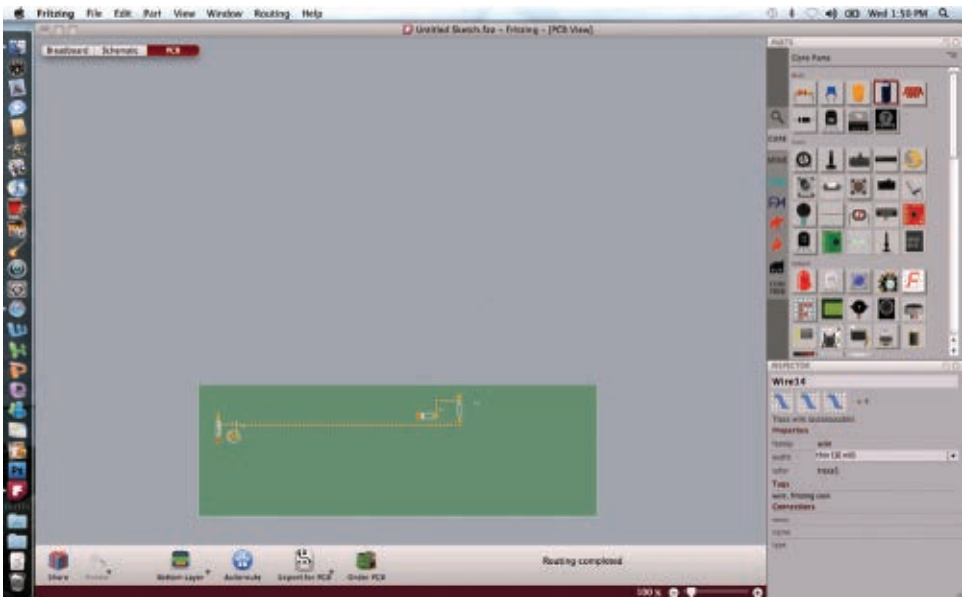
Digi-Key created the program late last year and offers unlimited free access in the form of a free download. All you have to do is register (make a username and password) and you will be able to create schematics with ease. (The download may be accessed at **www.digikey.com/schemeit**).

The initial screen — labeled New Project, with the usual address and menu bars and



SCREENSHOT 5. Fritzing's schematic view.

SCREENSHOT 6. Fritzing's PCB view.



SCREENSHOT 7. ExpressPCB offers free software that generates schematics and PCB layouts.

Digi-Key and Scheme-It logos — has four tabs across the top. These are Main, Object, Font, and BOM (Bill of Materials). From the last of these tabs, we get the idea that Digi-Key's rationale is not strictly humanitarian. It is to induce us to buy components from them.

The Main tab starts with a project category that includes Save, Save As, New, and Open. These respond as expected. The Save button brings up a dialog box with spaces for options to Cancel and Save. This will save the current project within the program, not to your computer. That operation is performed via File > Save As on your menu bar. Other options include the familiar New and Open. The next section under the Main tab is titled Output, and it has Export, Share, and Print options.

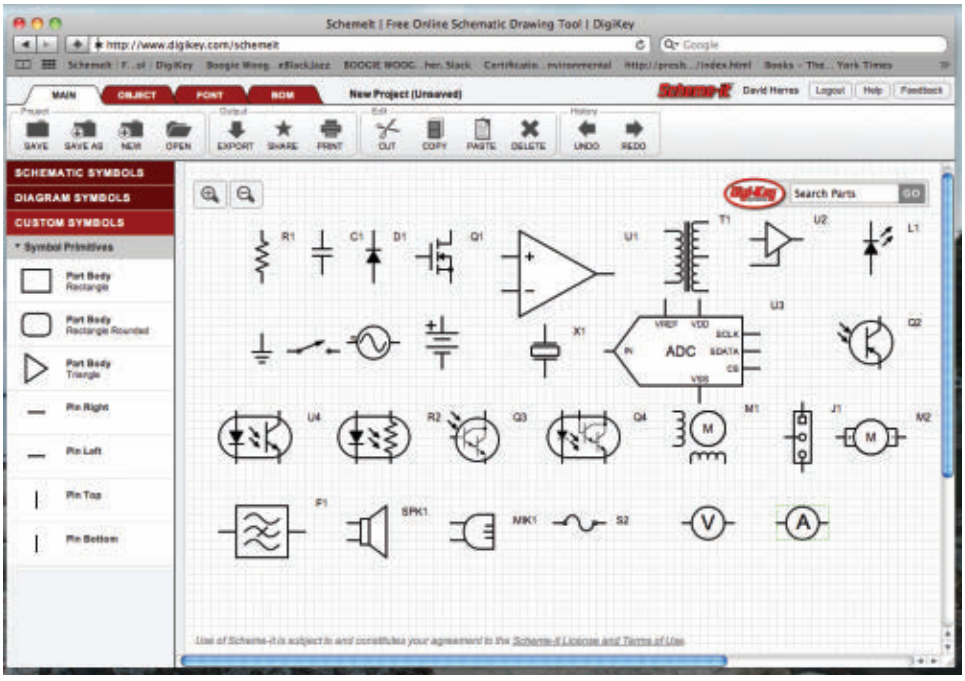
The Share button allows you to go public on the Digi-Key website; the correct link is given. Alternatively, the project may be sent via email to one or more colleagues, without appearing on the Digi-Key site. An Edit button permits Cut, Copy, Paste, and Delete actions; finally, the History button provides multi-level undo and redo actions, used extensively in creating a complex project.

The Object tab is next. Its first section is Group, with Group and Ungroup available as actions. The second section is Level, with Raise and Lower comprising the available modifications to the project. Transform allows users to Flip Vertical, Flip Horizontal, or Rotate in 90 degree increments. A section titled Align provides Left, Center, Right, Top, Middle, and Bottom options. The final section — Background — provides for Fill (which brings up a color selection in the style of Adobe Photoshop) and Gradient.

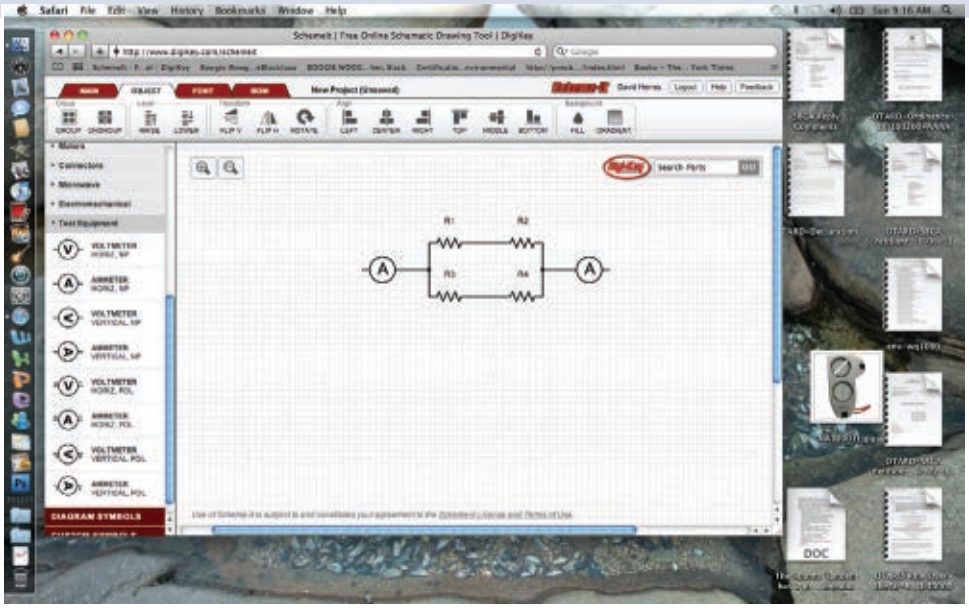
The next tab — Font — makes it possible to add text to the project, which is necessary for any schematic. Instructions for making this work are included in the Help document. The procedure is somewhat unusual, but fully workable. Text management options include Size and Color, Style (bold, italic, or underlined), Horizontal Align, and Vertical Align.

The final tab is called BOM (Bill of Materials). This is where users can purchase components from Digi-Key. Clicking the BOM tab brings up a screen displaying a list of all the components used so far in the schematic. There are spaces for Name, Value, your Part Number, Digi-Key Part Number, Description, and Notes. When the user clicks in any of these spaces, a small text field is created so that appropriate data may be entered and edited. When you get it the way you want it, hit the return button and it becomes permanent — at least until you select it with your mouse, whereupon the text becomes editable once more. (See **Figure 9**.)

The application also includes an integrated Digi-Key catalog with product photos and drawings. These may be dragged into the project so that they become part of the artwork.



SCREENSHOT 8. A few of Scheme-It's schematic symbols.



SCREENSHOT 9. A Scheme-It project. The schematic was created to illustrate resistors connected in a series-parallel configuration, with ammeters installed to demonstrate that current flow is the same at any point in a series circuit.

That's all there is to Scheme-It. The program is much simpler than Eagle and other schematic capture programs available. There is no simulation or PCB design capability, but it is free, makes clear, crisp, and professional schematics, and has a reasonably extensive symbol library. Additionally, it can be used to create various other (non-electronic) flow charts and block diagrams with colors, font sizes, and styles.

For one with modest computer skills, it is possible to get Scheme-It up and running in minutes, and perfect the technique before much time has elapsed.

FINAL THOUGHTS

As with all schematic capture programs, the user has to be self-reliant.

The Help documents, demos, and tutorials for most programs are either very scanty or — in the case of more full-featured applications like Eagle — they assume a high degree of knowledge concerning the very matters in question.

Once you get a foothold, it all becomes logical, but (with the exception of Scheme-It, perhaps) that will take some time and dedication. **NV**

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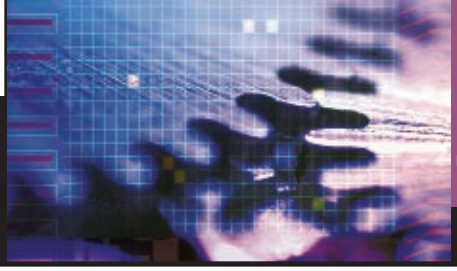


■ BY FRED EADY

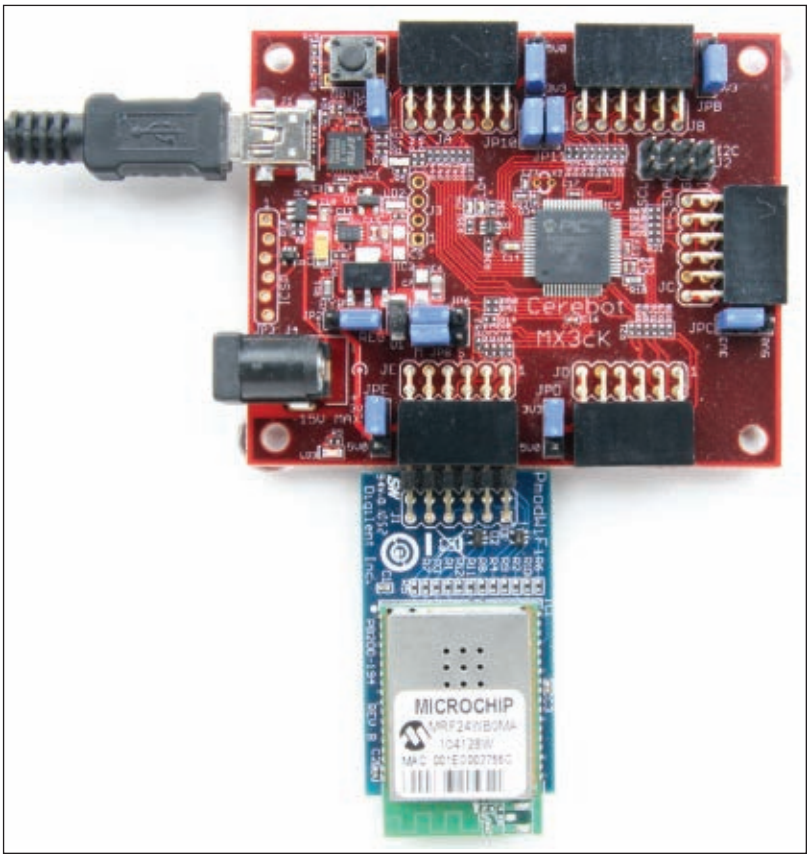
Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

CONTROL GADGETS WITH YOUR SMART PHONE

There weren't any high level compilers or "inos" for the early PIC microcontrollers. I recall attending the very first Microchip MASTERS Conference and writing assembler to complete the class demo projects. By the time I went to that MASTERS Conference, I had written so much PIC assembler that I could code the demo assembler projects on the fly without having to reference the assembler manual.

Easier is always better with it comes to programming. So, when BASIC and C started to float in and apply pressure to assembler coding, I was ready to jump ship. Suddenly, I could replace a dozen lines of assembler with a single line of C or BASIC. Although I couldn't just discard what I knew about PIC registers and mnemonics, things did seem to get easier with the advent of compilers.

Today, the purists still employ assembler in time sensitive routines because they believe it is faster and tighter than assembler code generated by a compiler. I don't really believe this is the case all of the time. My opinion is backed up by the new flavor of programming we are experiencing right now. "INO" programming methods are the rage these days. One has only to *sketch* out a program and the rest is magic. My first rule of embedded computing comes to mind: "Nothing is free." Let's see just how much "free." magic can exist in a sketch.



■ PHOTO 1. Our Cerebot MX3ck is equipped with a Digilent Wi-Fi Pmod. What you see is all of the hardware we need to monitor and control gadgets with a smart phone.

I PLEDGE ALLEGIANCE ...

... to the PIC microcontroller of Microchip in Arizona. For it can be manipulated with chipKIT magic. The "ino" in Arduino has come to the PIC by way of Digilent and MPIDE. Being from the old school, a "sketch" is something that is not quite all there. However, an ino sketch seems to contain everything including the magic of ino processing.

Digilent's Pmods are like candies in a box of chocolates. Unlike Forrest Gump's mother's view of chocolates, you know exactly what you're getting with a Digilent Pmod. One of my favorite Pmods is the PmodUSBUART. Just provide a six-pin SIP female header appropriately attached to

the target PIC's USART and you have instant serial portal access to the target PIC via the host PC's USB port.

This time around, I've decided to perform my magic act using a Digilent Cerebot MX3ck and Digilent's MPIDE. The Cerebot MX3ck is based on a PIC32MX320F128H. The 32-bit super PIC that powers the MX3ck brings an extra punch to ino development with its 128K of program Flash and 16K of SRAM.

With the PIC32MX320F128H's expansive canvas, I can put lots of detail into my ino sketches. In addition to the extensive memory resources, the PIC32MX320F128H provides the Cerebot MX3ck with 42 I/O pins and 12 analog inputs. The MX3ck you see in **Photo 1** can be powered via its USB portal or with an external power supply.

DRAGGIN' IN THE DROID

Being an old school guy, it took my flip phone's demise to force me into the teenage and equally corporate world of smart phones. After some serious shopping around, I decided to dive into the Android side and purchased a Motorola Droid Bionic. Wow! After sitting with my new toy all night long, I was glad to have finally caught up on the technology my kids and grandkids use every day.

I was disappointed that the Droid didn't have a regulation serial port because I would have liked to use this computing device (that is posing as a phone) in serial terminal applications. As it turns out, the Droid is actually the perfect terminal platform. Its web capabilities and built-in browser allow my Droid (and yours) to communicate with any device that can interoperate on an LAN or the Internet. With that, I've decided to put the computer side of my Droid cellular phone to work as the terminal element of a Wi-Fi controller. The controller portion of our Wi-Fi project will consist of a Cerebot MX3ck supporting a Digilent Wi-Fi Pmod. I'm going to forego the use on my PICkit3/MPLAB/PIC C compiler combination and instead turn to the magic offered by the new Digilent ino Wi-Fi library and the MX3ck's MPIDE programming interface.

THE FUN BEGINS

The Droid can fend for itself since everything we need to use it in this Wi-Fi control application is part of the Droid OS package. As for the MX3ck, we'll need to plug in that Wi-Fi Pmod and use the resources of MPIDE to build and load the 32-bit Wi-Fi controller code.

The MX3ck and Wi-Fi Pmod module will be programmed to form a TCP server that serves pages and receives commands from the Droid via its web browser. The TCP server interprets the command and acts accordingly. We'll start by crafting an ino sketch that illuminates or extinguishes one of the user-accessible LEDs mounted on the MX3ck, according to the command issued from the Droid's web browser. The folks at Digilent are giving us a foot up as they have released a Wi-Fi library that enables Cerebot MX3ck clients and servers using TCP and UDP protocols.

SETTING UP OUR NETWORK

We'll assemble a small network to support our baby steps into Wi-Fi control. I configured a standard wireless router to assume the SSID of "CEREBOT" with an IP address of 192.168.1.1. The Droid will receive its IP address from the wireless router which is acting as the network DHCP server. DHCP leases on our little network fall between 192.168.100 and 192.168.1.105. The MX3ck TCP server will be assigned a static IP address of 192.168.1.106 which is just outside of the DHCP server's lease range. To keep things as close to the accepted standards as possible, we'll use the standard HTTP port number of 80 to listen for commands from the Droid's web browser. Here's the code that accomplishes what we have just discussed:

```
IPv4 ipServer = {192,168,1,106};
unsigned short portServer =
DNETcK::iWellKnownPorts+ 79;      // port 80
```

IPv4 is a constant defined in the DNETcK chipKIT Internet Library and is used here to initialize the *IPv4* variable *ipServer* with our predetermined server static IP address. The *IPv4* constant represents a zero-filled constant and is defined in the DNETcK code like this:

```
const IPv4 DNETcK::zIPv4 = {0,0,0,0};
```

The DNETcK::iWellKnownPorts constant has a value of 1. So, to load our *portServer* variable with a port number of 80, we simply add 79 to the constant value of 1.

The SSID assignment is used by the DWIFIck chipKIT Internet Library. We set up our SSID in this manner:

```
// Specify the SSID
const char * szSsid = "CEREBOT";
```

The SSID we specify is used in the connection process which is also part of the chipKIT Internet library. In our project, we'll keep things simple and not use any security. So, our library connection code looks like this:

```
int DWIFIcK::connect(const char * szSsid)
{
    return(connect(WF_SECURITY_OPEN, szSsid,
    NULL, 0, 0, NULL));
}
```

Our application sketch code packs the DWIFIck library connect code snippet into a connection macro:

```
#define WiFiConnectMacro()
DWIFIcK::connect(szSsid, &status)
```

Note the addition of a status operator in the WiFiConnectMacro text. DNETck::STATUS is an enum found in the Internet library and is used to indicate the status of a task. For instance, a successful return code is 1. You can verify that in this partial list of status codes. The

complete list can be found in the DNETck.h library file:

```
typedef enum
{
     None                        = 0,
     Success,
     UDPCacheToSmall,

     // Initialization status
     NetworkNotInitialized,
     NetworkInitialized,
     DHCPNotBound,

     // Epoch status
     TimeSincePowerUp,
     TimeSinceEpoch,

     // DNS status
     DNSIsBusy,
     DNSResolving,
     DNSLookupSuccess,
     DNSUninitialized,
     DNSResolutionFailed,
     DNSHostNameIsNULL,
     DNSRecursiveExit,

     // TCP connect state machine states
     NotConnected,
     WaitingConnect,
     WaitingReConnect,
     Connected,
} STATUS;
```

If you need security, the chipKIT Internet library supports all of the common Wi-Fi security models. Depending on the security method you choose, the corresponding Internet library call will be executed and the WiFIConnectMacro will be modified accordingly.

CONNECTING TO OUR NETWORK

Our project sketch is based on the DWIFIck chipKIT library example sketch called TCPEchoServer. Both the original and modified sketch code flow are controlled by operational states. The application flow can be visually observed by activating the MPIDE's Serial Monitor tool:

```
typedef enum
{
     NONE = 0,
     INITIALIZE,
     LISTEN,
     ISLISTENING,
     AVAILABLECLIENT,
     ACCEPTCLIENT,
     READ,
     WRITE,
     CLOSE,
     EXIT,
     DONE
} STATE;

STATE state = INITIALIZE;
```

Here's what you'll see in the Serial Monitor window when the setup code begins:

```
MX3ck Wi-Fi Controller
Digilent, Copyright 2012
Modified by Fred Eady for Design Cycle 2012
```

The first order of business is to establish a connection. To do this, the WiFiConnectMacro is invoked:

```
     if((conID = WiFiConnectMacro()) !=
     DWIFIcK::INVALID_CONNECTION_ID)
```

If all goes as planned, a feel-good connection message will appear in the Serial Monitor window and a DNETck chipKIT library call is invoked to start our TCP server with the static IP address we specified earlier:

```
Connection Created, ConID = 1

   // intialize the stack with a static IP
    DNETcK::begin(ipServer);
```

This "begin" call is the final step in the setup portion of the sketch. The code then falls into the loop area of the sketch and verifies the connection:

```
    case INITIALIZE:
         if(DNETcK::isInitialzied(&status))
         {
              Serial.println("IP Stack
              Initialized");
              state = LISTEN;
         }
         else if(DNETcK::isStatusAnError(status))
         {
              Serial.print("Error in
              initializing, status: ");
              Serial.println(status, DEC);
              state = EXIT;
         }
         break;
```

The code will loop calling the *isInitialized* library function until either a valid connection is established or the task indicates a fatal error.

Once the stack has initialized, the server will start listening on the port we selected:

```
    case LISTEN:
         if(tcpServer.startListening(portServer))
         {
              Serial.println("Started
              Listening");
              state = ISLISTENING;
         }
         else
         {
              state = EXIT;
         }
         break;
```

Note that the startListening call is using our desired port of 80. However, before we can use this code, we must instantiate the tcpServer. I've got news for you. We're also going to need to instantiate the client server. So, we do that early in the code definitions like this:

```
TcpServer tcpServer;
TcpClient tcpClient;
```

The TcpServer instance uses a listen/accept process that starts listening on a local port (in this case, port 80). TcpServer allows the acceptance of a TcpClient. The TcpClient instance supports a communications session between the server endpoint pair (ipServer-192.168.1.106/portServer-80) and the client's endpoint pair. The Serial Monitor tool provides status and

debugging information. Turning on the Serial Monitor is optional. However, it's a good way of watching the application code bloom and tracking what is being sent and received. The following code snippet identifies the value of the *portServer* variable and indicates that the TCP server is listening:

```
case ISLISTENING:
     if(tcpServer.isListening())
     {
          Serial.print("Listening on port:
          ");
          Serial.print(portServer, DEC);
          Serial.println("");
          state = AVAILABLECLIENT;
     }
     else
     {
          state = EXIT;
     }
     break;
```

Nothing that looks like data we can use has been exchanged between the Droid client and the Cerebot MX3ck server. At this point, the Serial Monitor has given us all the information it has collected:

```
Connection Created, ConID = 1
IP Stack Initialized
Started Listening
Listening on port: 80
```

As soon as we issue a command from the Droid, the Droid becomes a possible client. Here's the code that will generate "Got 1 Clients pending" in the Serial Monitor window:

```
case AVAILABLECLIENT:
     if((count = tcpServer.availableClients
     ()) > 0)
     {
          Serial.print("Got ");
          Serial.print(count, DEC);
          Serial.println(" clients pending");
          state = ACCEPTCLIENT;
     }
     break;
```

If nothing weird happens to the connection, the TCP server will accept the pending client. A timer is started to kill the session if the pending client doesn't cough up some data in a reasonable time:

```
     if(tcpServer.acceptClient(&tcpClient))
     {
          Serial.println("Got a Connection");
          state = READ;
          tStart = (unsigned) millis();
     }
```

The Serial Monitor reflects the status of the application up to this point:

```
Got 1 clients pending
Got a Connection
```

Here's what we've been waiting for. The Droid has probably sent some data to the TCP server. The number of bytes transferred from the Droid client is captured in the variable *cbRead*:

```
case READ:

     if((cbRead = tcpClient.available()) > 0)
     {
          cbRead = cbRead < sizeof(rgbRead)
          ? cbRead : sizeof(rgbRead);
          cbRead = tcpClient.readStream
          (rgbRead, cbRead);

          Serial.print("Got ");
          Serial.print(cbRead, DEC);
          Serial.println(" bytes");

          state = WRITE;
     }

     // If too much time elapsed between
     // reads, close the connection
     else if( (((unsigned) millis()) -
     tStart) > tWait )
     {
          state = CLOSE;
     }
     break;
```

The Serial Monitor is earning its money and verifies the reception of command data from the Droid client:

```
Got 465 bytes
```

Now, it's the TCP server's turn to perform some magic. Before we slice the steak, though, let's see what the Droid sent:

```
case WRITE:
     if(tcpClient.isConnected())
     {
          Serial.println("Writing: ");
          for(int i=0; i < cbRead; i++)
          {
               Serial.print(rgbRead[i], BYTE);
          }
          Serial.println("");
```

We really don't need to see all 465 bytes. We're only interested in the command line data portion of the payload sent by the Droid. The command should follow the "GET /" sequence:

```
Writing:
GET / HTTP/1.1
```

DOING SOME REAL WORK

I haven't punched up the LED submit button on the Droid browser yet. So, the absence of a command is the correct thing to expect. However, the Cerebot MX3ck TCP server did send a web page back to the Droid client when it initially connected:

```
          bufptr = 0;

          if(strncmp("GET / ",(char *)&(
          rgbRead[bufptr]),6)== 0)
          {
               send_webpage(0);
               state = READ;
          }
```

According to our Serial Monitor output, the TCP

server received the "GET / " string. So, the send_webpage(0) statement was executed. All of the web page data used by the send_webpage() function is stored in program Flash. You can get the TCP server's Flash web page contents from the download package. Here's how the send_webpage() function is coded:

```
unsigned int send_webpage(byte cur_state)
{
     Serial.println("Writing webpage: ");
     sendlen = send_rom_msg(webpage);
     Serial.println("");
     Serial.println("Writing viewport: ");
     sendlen = send_rom_msg(viewport);
     Serial.println("");
     Serial.println("Writing method: ");
     sendlen = send_rom_msg(method);
     Serial.println("");
     Serial.println("Writing ledstate: ");
     sendlen = send_rom_msg(ledstate);
     Serial.println("");

     switch(cur_state)
     {
          case 0: //LED OFF
              Serial.println("Writing ledoff: ");
              sendlen = send_rom_msg(ledoff);
              Serial.println("");
         break;

        case 1: //LED ON
              Serial.println("Writing ledon: ");
              sendlen = send_rom_msg(ledon);
              Serial.println("");
         break;

     }
}
```

Invoking send_webpage(0) sends a web page to the Droid with an LED status of OFF. The Droid is presenting that web page to us in **Photo 2**. This is what executes in the WRITE case code when I punch the ILLUMINATE button:

```
                else
                {
                    cmd = get_cmd((char
                    *)&(rgbRead[bufptr+5]));

                    switch (cmd)
                    {
                     case 0:
                       digitalWrite(PIN_LED1,LOW);
                      break;

                      case 1:
                       digitalWrite(PIN_LED1,HIGH);
                      break;
                    }

                    send_webpage(cmd);
                    state = READ;
                    tStart = (unsigned) millis();
                }
        }
```

The "GET /?cmd=1" string is sent by the Droid when the ILLUMINATE button is pressed. The TCP server's job is to ferret out that 1 which represents the command to illuminate the Cerebot MX3ck's LED.

To find the 1, we must tell the get_cmd function where to begin looking by setting the buffer location pointer (bufptr) to point at the character that follows the "/" in the command line. Once we have done that, we can turn the get_cmd function loose:

```
byte get_cmd(char *starting_cmdline_loc)
{
         byte parsed_cmd = 0xFF;

         if (parse_cmdline(starting_c
         mdline_loc,"cmd"))
         {
                  if (*cmdbuf < 0x3A
                  && *cmdbuf > 0x2F)
                  {
                       parsed_cmd=(*cmdbuf-0x30);
                       return parsed_cmd;
                  }
                  else
                  {
                      return(0xFF);
                  }
         }
}
```

The get_cmd function uses the services of the parse_cmdline function to extract the value of the command variable (cmd) from the Droid's command line.

Here's how the parse_cmdline function works. The parse_cmdline's "cmd" argument represents a null terminated string (cmd\0 or 0x63 0x6D 0x64 0x00). The parse function simply walks through the command line beginning at the location specified by bufptr until it encounters the "c" in the command line string. It then moves to the next

■ PHOTO 2. You can code the server HTML to your project's specifications. Here, I have just enough HTML to get the message across.

■ PHOTO 3. It's ON! Note the LED is illuminated just to the right of the PIC.

character looking for an "m." If an m is not encountered, it resets and starts looking for a c again.

Once the parse routine walks through a succession of characters that make up cmd, the next character it encounters should be a NULL or 0x00. If the cmd string followed by a NULL is discovered, the command line pointer should be positioned at an "=" character. Our command just happens to be a single character in length that follows the = character. Multiple character commands can be accommodated as the parse_cmdline function sifts the parsed command string into a 64-character buffer.

Once a command has been extracted from the command line, the TCP server executes the command. Here's where the real heavy lifting is done:

```
switch (cmd)
{
  case 0:
        digitalWrite(PIN_LED1,LOW);
    break;

    case 1:
        digitalWrite(PIN_LED1,HIGH);
    break;
}

send_webpage(cmd);
```

Depending on the value of the command, the LED is either illuminated or extinguished. Once the LED has been serviced, an updated web page image is transmitted as shown in **Photo 3**.

JUST THE BEGINNING

Many a project has evolved from just learning to blink an LED. If we can use a smart phone browser to control an LED via one of the Cerebot MX3ck's I/O pins via Wi-Fi, why can't we energize a relay, turn on a MOSFET, read an analog input, or send a PWM value? The answer is ... we can. Embedded Wi-Fi control is now a part of your Design Cycle. **NV**

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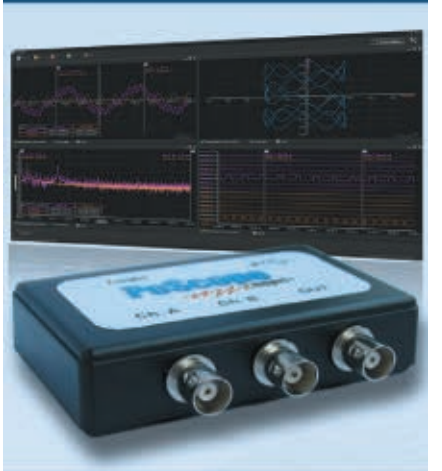

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NEAR SPACE

APPROACHING THE FINAL FRONTIER

■ BY L. PAUL VERHAGE

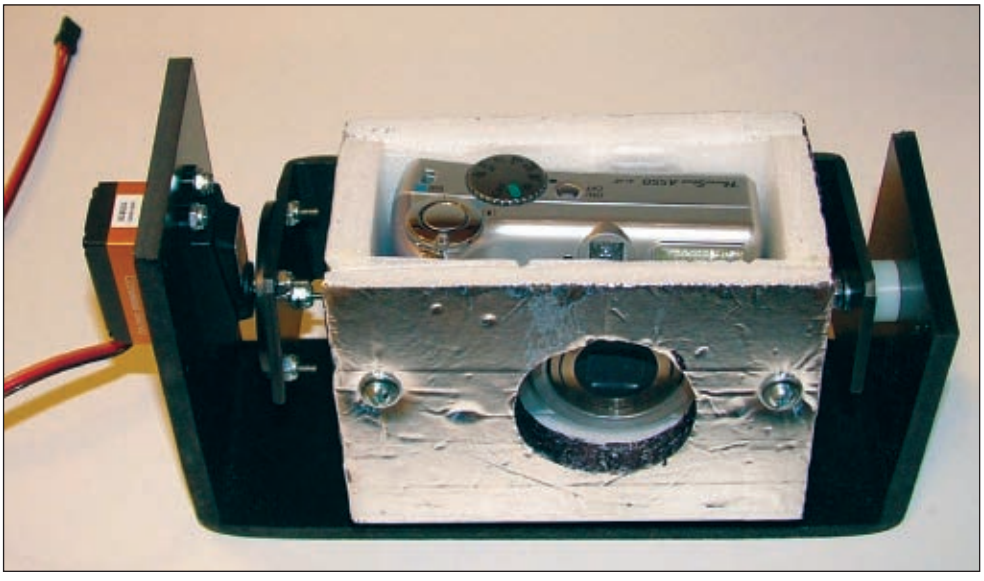
Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

MAKING ONE CAMERA DO THE WORK OF THREE

There are so many things to see in near space, that we could justify attaching multiple cameras to each near spacecraft. For example, people want to record images of the ground, take pictures of the horizon, and watch the balloon expand and burst. We can accomplish this goal by attaching one camera and rotating it between pictures. With the availability of large SD memory cards, there's no reason that a single camera can't record all the images we might want. This month, I'll show you how to build an inexpensive camera rotator. By using one, a less expensive mission can do the work of three.

I built my first camera rotator because I couldn't afford three cameras. I built my latest one because the camera rotator reduces the payload mass and cost of a mission. Since I attach experiments to the faces of my near spacecraft, using one camera in place of three also permits me to add additional experiments to the near space mission. A camera rotator has the benefit of allowing cameras to point in any angle with just a change in the operating software. This creates opportunities for sensors to dictate where cameras are positioned during a mission. That's something that a stationary camera can't do.

The camera rotator consists of three parts joined by a servo and bolts. There's a camera box for keeping the camera warm and protected. The camera box sits within a camera cradle with one axis of rotation. The cradle is rotated by a servo attached to a bracket. Experiments like the camera rotator attach to the side of a near spacecraft. Since the size of each component of the rotator (camera box, cradle, and bracket) depends on the part it's holding, we'll assemble the camera rotator by working from the center, outwards.



■ **FIGURE 1**. One camera doing the work of three. For this project, I am using a Canon PowerShot A550. The Canon Hacker Development Kit (CHDK) is installed on this camera and the script I have loaded triggers the camera to take pictures when a five volt signal is sent over its mini USB cable.

CAMERA BOX

Start by building a Styrofoam box to fit your camera of choice. For this project, I recommend using 10 mm thick sheets of Cellfoam 88. This Styrofoam sheeting is available at many hobby and craft stores. It's a hard

Styrofoam with a smooth face. The faces are made that way by pressing a hot metal surface against the sheet. The heat slightly melts the face of the Styrofoam and seals its open cells. The result is a surface that's between Styrofoam and a sheet of Styrene plastic. I have found I can glue a sheet of Styrene to the face of Cellfoam 88 with plastic model cement (which melts Styrene) without dissolving the Styrofoam. However, don't apply model cement to the edges of Cellfoam 88. It's a regular Styrofoam and the cement will dissolve the open cells within the foam leaving huge gaps.

The box needs five sides glued together. The top will be made later and isn't permanently attached like the other sides. Use hot glue to assemble the sides of the camera box. Then, cut out a round opening for the camera lens. Make the lens opening smaller than it needs to be. That way, if you mis-measure the placement of the opening, you can correct it as you make the final trim for the opening. If your camera has a light meter that's separate from the camera lens, then make sure you cut an opening for it also. Finish the openings by coloring their interior edges with a black marker. The black will help remove some of the sun's glare from your photos. After its completion, the camera box is bolted to the camera cradle. I found that I could use two 6-32 bolts, three inches long as my cradle bolts. Drill or melt two small holes through the box for the cradle bolts. Instead of drilling the box on a drill press, I used a hot cutter made for Cellfoam 88 called a Styrocutter.

Chances are you will find this cutter where you purchased your Cellfoam 88 sheets. The cutter consists of a single brass tube projecting from the handle. The hot brass tube can melt holes four and a half inches long. Position these two holes so the bolts will be embedded in the Styrofoam sides. That will leave the camera box's interior volume free for the camera.

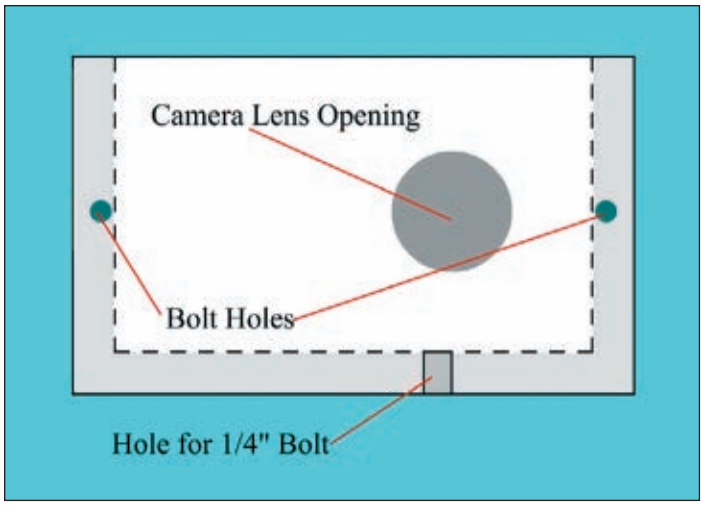
The last hole to make in the camera box is one for the 1/4"-20 bolt that's used to attach the camera to a camera tripod. Always use this bolt to attach a camera to the airframe. The bolt ensures the camera can never fall away from the near spacecraft. Measure the position of this hole carefully. Again, make this opening small so you can adjust the hole if it's off center.

Finish the camera box by wrapping it in tape. In my rotator, I used aluminum duct tape. Since potatoes are baked in aluminum foil, I figure the aluminum coating will help keep the camera warmer in near space.

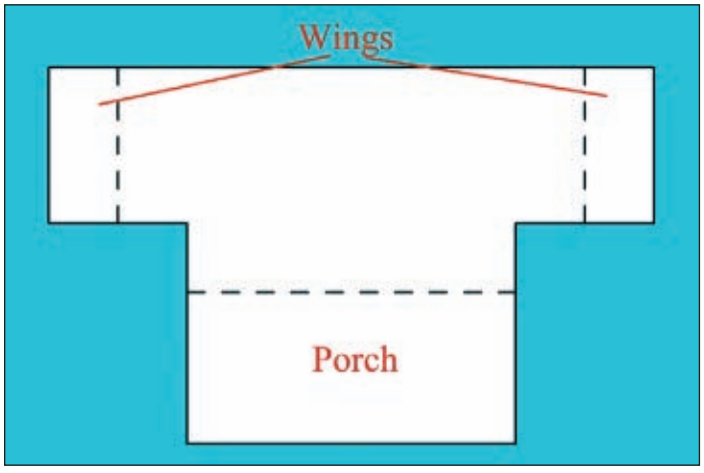
CAMERA CRADLE

Now that the size of the camera box is known, it's time to construct the camera cradle. The cradle holds the camera box so it can be rotated by the servo. I constructed my cradle from 1/8" thick Syntra plastic, but I suspect metal would be better. Therefore, if you have access to a sheet metal brake, you might try using it to make the cradle.

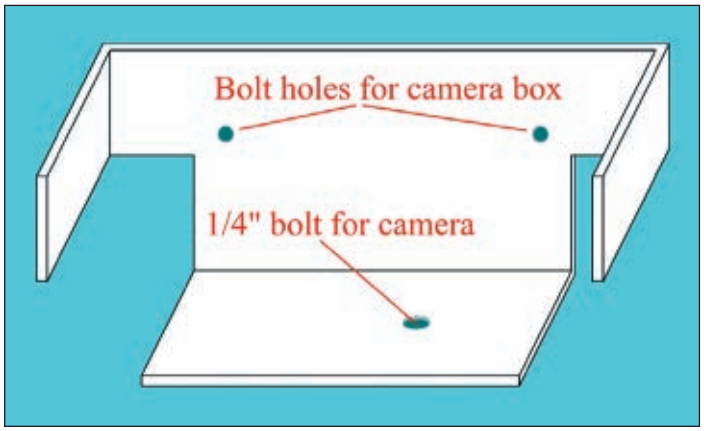
The cradle has two wings and a porch. The camera



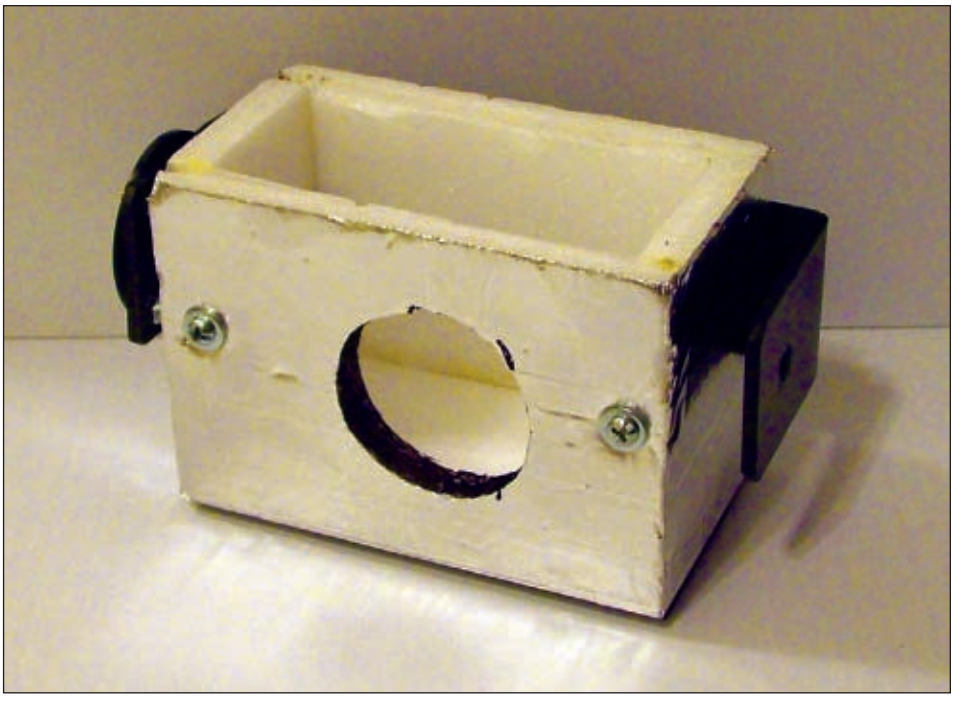
■ **FIGURE 2.** A front view of the completed camera box. Note that the holes for the cradle bolts are drilled through the Styrofoam sides where they can't interfere with the camera inside the box.



■ **FIGURE 3.** The dimensions of your cradle will depend on the camera box and ultimately the size of your camera. The porch is large enough for the camera box to sit on it. The dotted lines are where you will bend the cradle into shape. All bend angles are 90 degrees.



■ **FIGURE 4.** After bending the cradle, set the camera box on the porch and push its back up against the back of the cradle. Locate where the cradle bolts will attach the camera box to the cradle and drill those holes. Then, drill a larger hole through the porch for the 1/4"-20 bolt used to attach the camera to a tripod.



■ **FIGURE 5**. Now you can attach the camera box to the cradle with the two cradle bolts. Use washers — preferably fender washers — on the cradle bolts because they spread the pressure of the bolts and prevent them from crushing the foam camera box. Use stop nuts on the cradle bolts, rather than regular nuts. The nylon inserts will make sure they can't come loose during a mission.

box rests on the porch and the cradle rotates on an axis running through the two wings. The porch should be as wide as your camera box, but the wings only need to go a little past the center of the camera box. The images in **Figures 3**, **4**, and **5** show the steps needed to construct the cradle.

After completing the camera box and cradle, load the camera into the box and test its fit. Then, get a rough idea of where the center of gravity runs through the camera. The exact center isn't needed but if you can, set the cradle's rotational axis to run closely through the camera's center of gravity; it will make it easier for the servo to rotate the camera. After locating it, drill small holes in the cradle wings where the rotational axis is supposed to be located.

Attach a servo horn to one wing of the camera cradle. This will be the driven axle. In order to keep the servo horn properly aligned while making the holes, use a 2-56 bolt and nut to attach the center of the servo horn to the cradle wing. Then, drill four holes through the horn and cradle wing. I use a 1/8" bit to drill the holes through the servo horn and cradle wing, and 2-56 bolts and nuts to attach the servo horn. Be sure to use stop nuts to attach the servo horn to the cradle. After attaching the servo horn, remove it and enlarge the center hole in the cradle (the one you used to hold the servo horn in place while drilling holes). This hole must be large enough for a servo horn bolt to pass through.

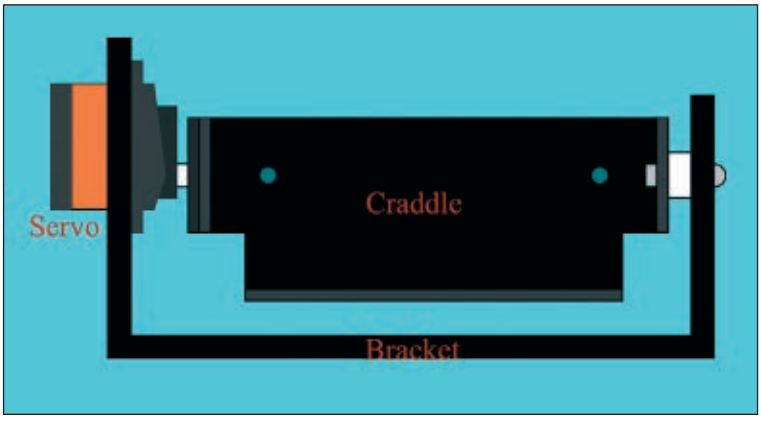
After attaching the servo horn to one wing of the cradle, drill the hole in the other wing for the bolt you have decided to use for the freely spinning axle.

BRACKET

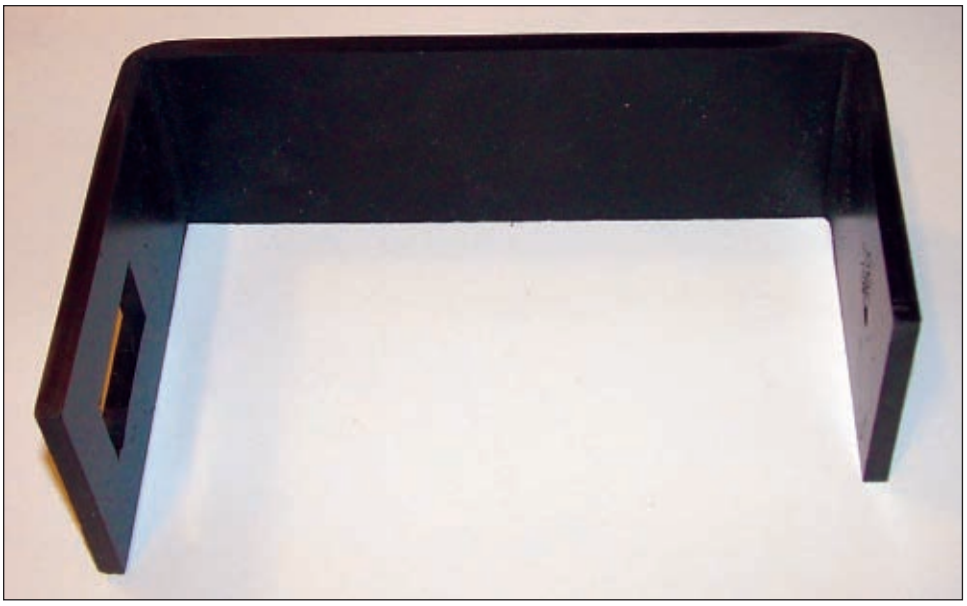
Finally, we can make the bracket. For my bracket, I used 1/4" thick Syntra plastic. I selected it because this time, I wanted something stiffer than the 1/8" Syntra. I figure the thicker Syntra is more important since the bracket takes the majority of the stress in the camera rotator. Again, if you have access to a sheet metal brake, you might want to try using metal for your bracket.

You should have the servo you want to use for the rotator. I recommend using something strong, with ball bearings and metal gears. I've used traditional plastic gear servos in the past and was satisfied with the results. However, this time I am using a heavier and more expensive camera inside my rotator. So, for this project, I selected a Savox SC-1258 TG — a nice strong servo.

The bracket is just a "C" shaped piece of plastic. It has two arms: one to hold the servo and the other to hold the axle bolt. You'll need to look at your cradle's dimensions and the placement of the servo in order to determine the size of your bracket. The cradle sits freely inside the bracket. The bracket needs to be wide enough that the servo — bolted into one of the bracket's arms — can rotate the cradle and a nylon spacer can fit between the bracket's other arm and cradle. Use a nylon spacer to reduce rotational friction and to fill the gap



■ **FIGURE 6**. The servo — which is mounted to the bracket — is attached to the camera cradle with a servo horn. The other axle is free to spin as the servo rotates the cradle.



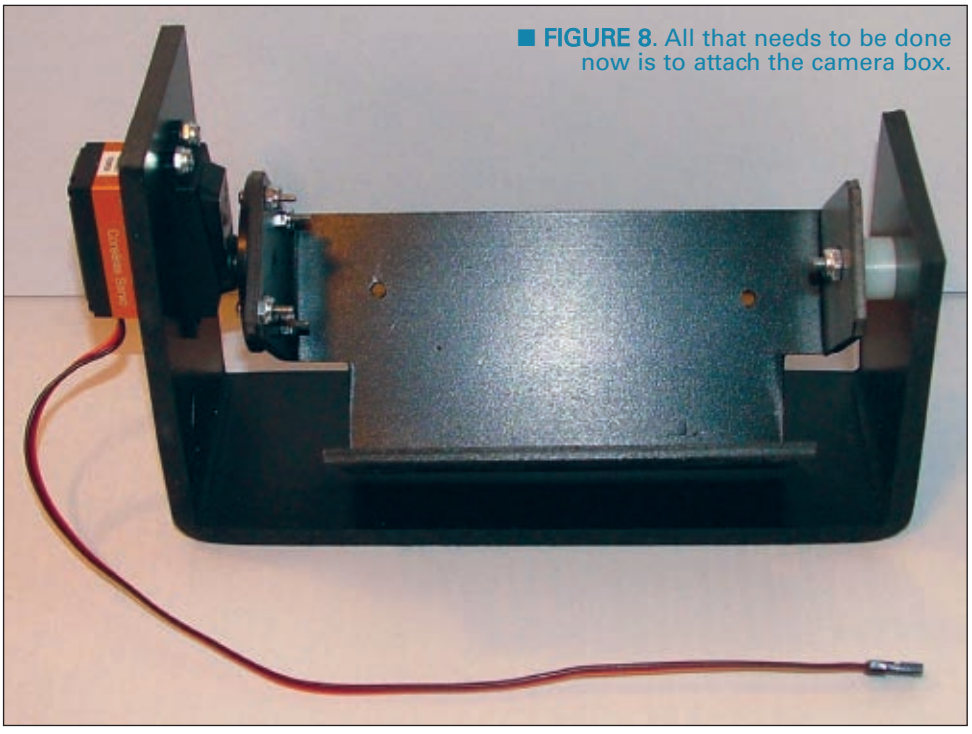
■ **FIGURE 7.** This is the bracket after it is bent, slotted, and drilled. The slot holds the servo. There are small mounting holes next to the servo slot where the servo is attached to the bracket.

between the other bracket arm and cradle wing. I am using a 6-32 bolt for the freely rotating axle.

Now that you know where the servo and free spinning axle are located relative to the bracket, cut out and bend the bracket. Cut a slot in the bracket's servo arm just large enough to mount the servo. Then, drill four holes around the servo slot to mount the servo to the arm of the bracket. Drill a hole in the other arm of the bracket (the axle arm) that lines up with the axle bolt in the cradle.

Now you're ready to attach the cradle to the bracket. First, use a spare servo horn and rotate the servo to its central position. Then, hold the cradle in its central position and slip it onto the servo horn and screw in the servo horn bolt. On the axle arm, hold the nylon spacer between the cradle and bracket, and slide the axle bolt through both. Use a stop nut on the axle bolt, but don't over-tighten it. The nut should just be tight enough to take out the slack, but loose enough that the servo can still rotate the cradle. Without the camera box in place, the camera cradle and bracket will look like **Figure 8**.

Connect the servo to a flight computer and write a



■ **FIGURE 8.** All that needs to be done now is to attach the camera box.

Every summer, amateur near space enthusiasts meet to discuss the current state of the art and to launch weather balloons. This event is called the Great Plains Super Launch, or GPSL. This year, the Nebraska Stratospheric Amateur Radio group is hosting GPSL in Omaha. The date for GPSL this year is June 7-10. If you have an interest in exploring this great hobby and educational activity, you should plan to attend. Venue information and registration can be found at **www.superlaunch.org**. If you do attend, be sure to look for me.

program to test the rotation of the cradle. If everything looks fine, then bolt the camera box to the cradle. Slip the camera into its box and attach it with a 1/4"-20 bolt. Since the camera bolt is holding the camera to the rotator, the camera box cover doesn't have to be held on very strongly. Therefore, I just wrap a new rubber band over the camera box and cover. Now, you just need to attach your camera rotator to your airframe and begin taking pictures from near space.

Onwards and Upwards, Your near space guide **NV**

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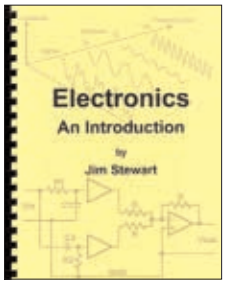

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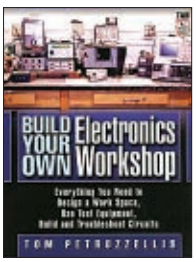

This value-packed resource provides everything needed to put together a fully functioning home electronics workshop! From finding space to stocking it with components to putting the shop into action — building, testing, and troubleshooting systems. This great book has it all! And the best part is, it shows you how to build many pieces of equipment yourself and save money, big time!

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by Thomas Kibalo

NEW!

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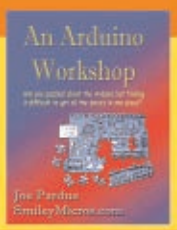

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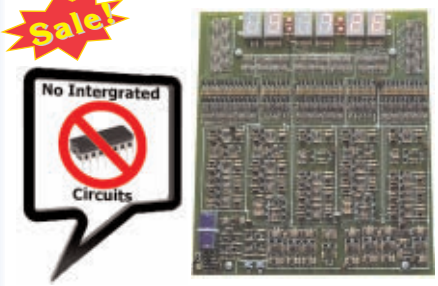

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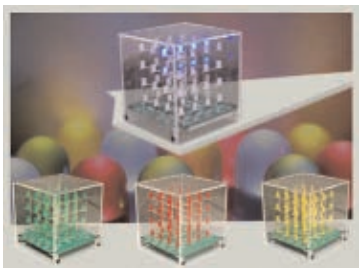

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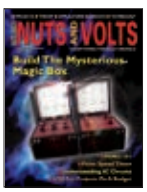

As seen on the April 2007 cover.

This unique DIY construction project blends electronics technology with carefully planned handcraftsmanship. This clever trick has the observer remove one of six pawns while you are out of the room and upon re-entering you indicate the missing pawn without ever opening the box.

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As seen in the July 2011 issue.

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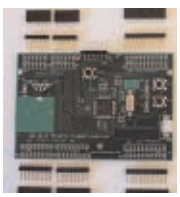

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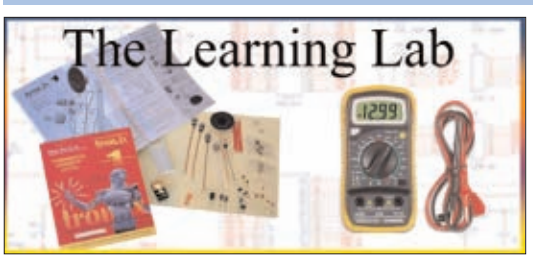

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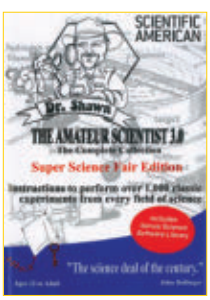

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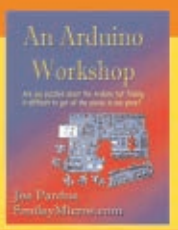

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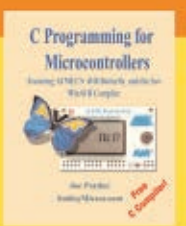

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#46 SMILEY'S WORKSHOP

C PROGRAMMING - HARDWARE - PROJECTS

by Joe Pardue

Chaser Light Marquee – Part 2

Follow along with this series! Joe's book & kits are available at www.nutsvolts.com

Discuss this article in the *Nuts & Volts* forums at http://forum.nutsvolts.com.

Recap

Last month, we went a little deeper into pointers and started on the Chaser Light Marquee Frame project. This month, we are going to go even deeper into pointers and finish up the hardware project. Note that this month the theory and lab sections are only loosely related, much like broccoli and coconut pie. Eat your healthy theory first, then you can have your tasty lab for dessert.

Theory

I strongly suggest that you read the Simple Chaser Light Kit sections of Smiley's Workshops 44 and 45 (March and April *Nuts & Volts*) before continuing. If you don't have those issues, you can find the materials at **www.smileymicros\blog**. By the way, I keep repeating this but there will be a lot of repetition in this discussion of pointers since I think it is a difficult concept. If you've got a concept, then just skim the repetition and bear with those of us who are using duller pencils.

What are Pointers in Hardware?

A pointer is the address of some data.

Store 'S' (0x53)(1010011) at address 12708 (0x31A4) (11000110100100)

Even though pointers were difficult for me to grasp, I think that they may be even more difficult for contemporary novices who did not get the experience of programming computers with switches like we dinosaurs got. Let's look at the seemingly simple task of loading the string 'Smiley Micros.' We'll load the first character 'S' into memory at address 12708 on a switch programmed computer. **Figure 2** shows the toggle switches on the SWITCH REGISTER set to 00000000001010011 which is the ASCII code for S in binary. You can see that the SWITCH REGISTER corresponds to the data line of lights, with the up switch toggles showing a red light and the down toggles showing no red light. In the prior operation using the toggle switches, we set the ADDRESS REGISTER to the address 12708 that is binary 0000110001101000100. You can see in the **figure** that there are two registers associated with the data value for S: one is the data itself and the other is the address of that data. In order to input some simple text into this machine, we would be standing in

■ FIGURE 1. DIY chaser light marquee.

front with a clipboard that has the text to input: 'Smiley Micros' in binary so that we can enter it on those PDP11 switches. As you can see from **Table 1**, you've got 13 binary numbers, each with eight bits meaning that you have to correctly set 104 switch positions just for the text. I also have to set the sequential address of each byte in memory — a bunch more switch toggles. That is a lot of work and it is very error prone, all just to load the text Smiley Micros into memory. It is truly a wonder that anyone ever got these things to work.

Now, my purpose here is not to bore you with elder programming war stories [I had to walk five miles through the snow to program computers when I was a kid — and it was uphill both ways!]. I just want to help you to become clearly aware that the data and the address of that data are separate entities. Each is a form of data that has to be stored somewhere in the computer. As we showed earlier, in C the data is kept in variables with a data type of char, used as:

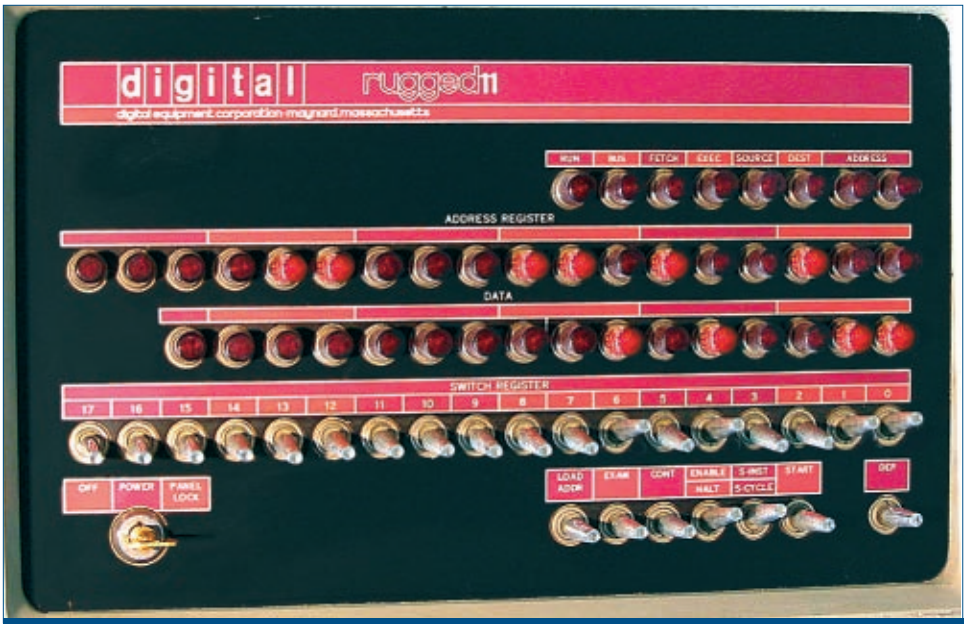
```
// declare a char variable and set it to 'S'
char myVariable = 'S';
```

C converts characters delimited with single quotes to the hexadecimal value of that character:

```
char myVariable = 0x53; // same as 'S'
```

The program text 'myVariable' is internally an alias for the address of the variable and the 0x53 is the data stored at that address. Make sure you understand this. The variable name is an alias for our convenience so that C understands it to be the address for the variable. So, instead of having to remember that my variable, myVariable, is stored at address decimal 12708 (or worse, binary 11000110100100), we can tell C that when it sees the word myVariable it knows that I mean the address 12708. When I assign a value to myVariable as I did with myVariable = 'S', **C knows to store the ASCII value (0x53) of S at the memory location 12708**. Got it so far?

Next, we will see how to use that address as a variable. Don't get confused here. The data at an address is a variable, but the address of that data can also be considered a variable. In our case, the data variable is one byte and the address variable is two bytes. Considering an address as a variable can come in very handy, as you'll see later when handling large blocks of continuous data.



■ FIGURE 2. PDP11 front panel.

A pointer is a variable that can hold an address of another variable. We can define a pointer for a character as follows:

```
// declare a variable that will contain the
// address of a char
char *myPointer;
```

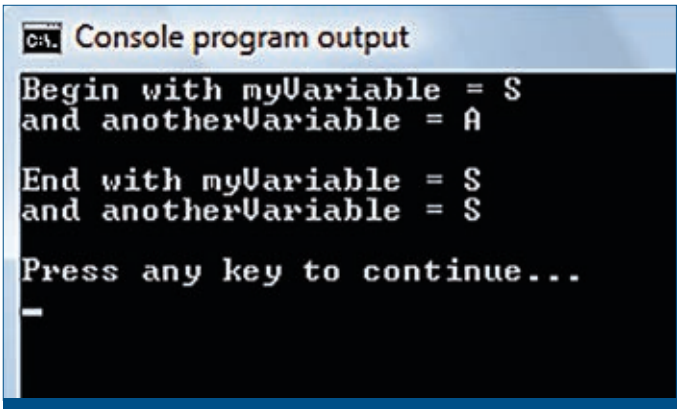
The '*' operator instructs C that this is a pointer to a character. If we want to get this to point to the character we defined above, we write:

```
// set myPointer to the address of myVariable
myPointer = &myVariable;
```

If we want to use myPointer to reference the data in

CHAR	HEX	BINARY
S	0x53	01010011
m	0x6D	01101101
i	0x69	01101001
l	0x6C	01101100
e	0x65	01100101
y	0x79	01111001
space	0x20	00100000
M	0x4D	01001101
i	0x69	01101001
c	0x63	01100011
r	0x72	01110010
o	0x6F	01101111
s	0x73	01110011

Table 1. Smiley Micros in hex and binary.


Console program output
Begin with myVariable = S
and anotherVariable = A
End with myVariable = S
and anotherVariable = S
Press any key to continue...

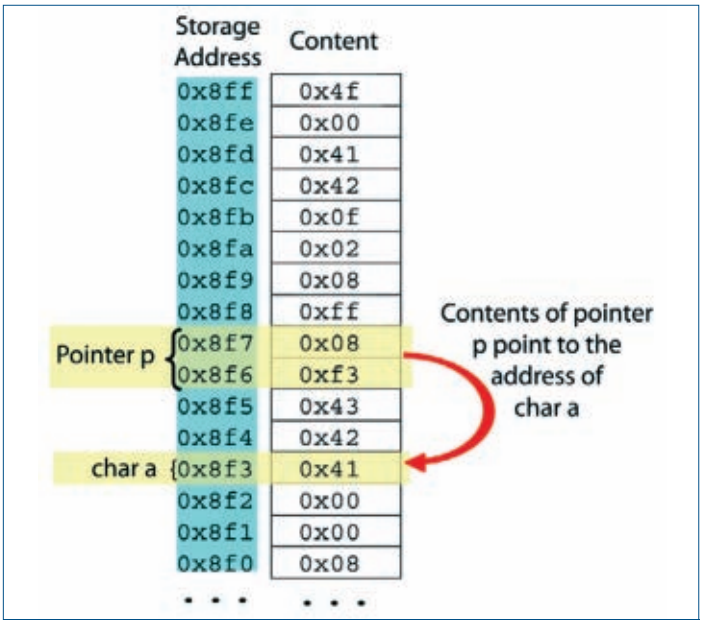
■ FIGURE 3. First pointers demo.

the variable myVariable, we dereference the pointer as follows:

```
// define anotherVariable to hold the data 'A'
char anotherVariable = 'A';

// load anotherVariable with the char pointed to
// by myPointer
anotherVariable = *myPointer;
```

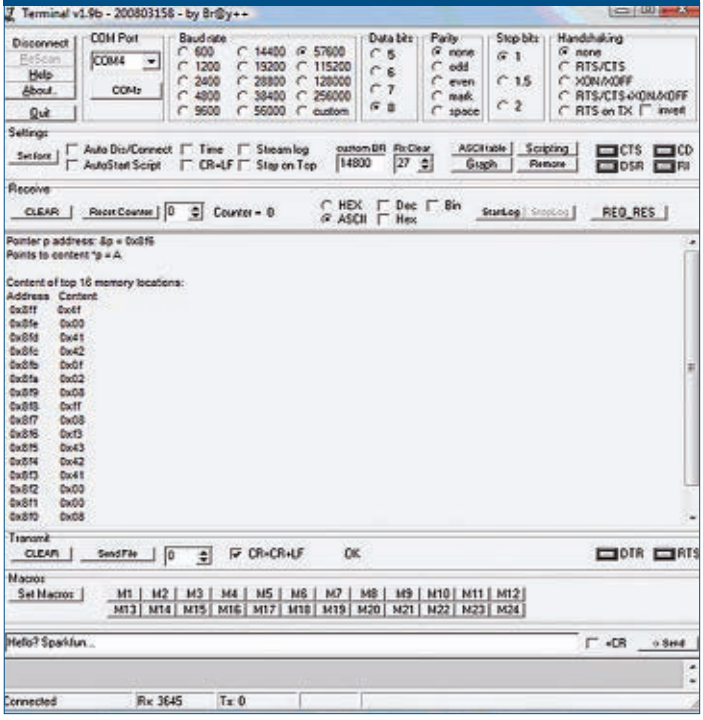
Now, anotherVariable hold the data 'S.' Let's run this in Pelles C (discussed last month) just to make sure:

```
// Comments removed for brevity
#include <stdio.h>

int main()
{
  char myVariable = 'S';
  char anotherVariable = 'A';
```



■ FIGURE 4. Pointers in AVR memory.

■ FIGURE 5. Output from pointer_test on Bray's Terminal.



```
  char *myPointer;

  printf("Begin with myVariable =
  %c\n",myVariable);
  printf("and anotherVariable =
  %c\n\n",anotherVariable);

  myPointer = &myVariable;

  anotherVariable = *myPointer;

  printf("End with myVariable =
  %c\n",myVariable);
  printf("and anotherVariable =
  %c\n\n",anotherVariable);
}
```

The results are shown in **Figure 3**.

Pointers With AVRStudio

We can write another simple program for the AVR to also illustrate this:

```
#include <stdio.h>
#include "c:\avrtoolbox\libavr\source\driver
\usart\usart.h"

int main()
{
  // Initialize usart for printf
  usart0_init_baud(57600);

  // Declare a char variable and set it to 'S'
  char myVariable = 'S';
  // Declare a pointer to char by using *
  char *myPointer;

  // Get the address of the char variable
  // Note that there is no * on the pointer name
  myPointer = &myVariable;

  // Use the pointer to get contents of
```

```
'myVariable'
  // Note that this does require the *
  printf("myPointer points to:
  %c\n",*myPointer);

}
```

The output is: `myPointer points to: S`

One More Time

Understand that a pointer is the address of a location in memory. Ordinary variables are data, while pointers are variables that contain the address of other variables. The data you want is in memory and the address of that data is a pointer to that data. Note that the data that a pointer points to can also be a pointer. You define a pointer variable with * and you extract the address of an ordinary variable with '&.' Note that you do not use the * on the pointer when you get the address of the variable using the &:

```
char myVariable = 'S';
char *myPointer;

myPointer = &myVariable;

printf("myPointer points to:
%c\n",*myPointer);
```

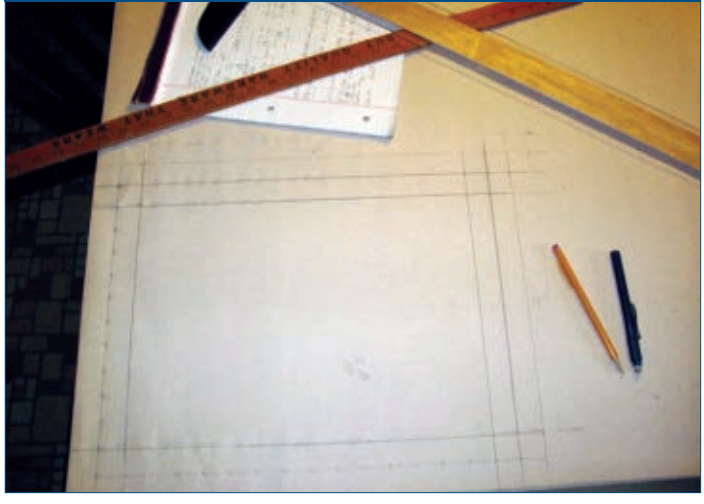
We saw **Figure 4** last month. It shows a block of ATmega328 SRAM memory where we see the highest 16 memory locations, and we note that the pointer p — which is two bytes long — is located at addresses 0x8f6 and 0x8f7. It has been set to point to the char a located at 0x8f3. You will also see that the data in 0x8f6/7 is the address of the char a. Next month, we will see that the * operator tells C to use the address stored at the pointer location to get the data at that pointed-to address, which is 0x11. Well, this is all very illustrative, but how did we get the data for this illustration in **Figure 4**? It comes from the following:

```
#include <stdio.h>
#include "c:\avrtoolbox\libavr\source\driver\
usart\usart.h"

void printMyBlock(char *p,int mB);

int main()
{
  // Initialize usart for printf
  usart0_init_baud(57600);

  char a = 'A';
  char b = 'B';
  char c = 'C';
  char *p;
  char *q;

  // Point to top of SRAM
  q = (char *)0x8ff;
  // Point to the char a;
  p = &a;

  printf("Pointer p address: &p = %p\n",&p);
  printf("Points to content *p = %c\n",*p);

  printf("\nContent of top 16 memory
  locations:\n");
  printf("Address   Content\n");

  printMyBlock(q,16);
}

void printMyBlock(char *p,int mB)
{
  for(int i = 0 ; i < mB ; i++)
  {
       printf(" %p        0x%02x\n",p-i,*(p-i));
  }
}
```

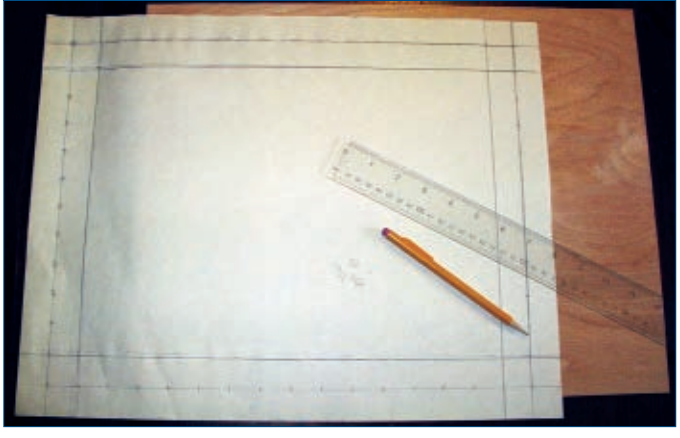
You should pay careful attention to how we use pointers to access sequential locations in memory using *(p-1), where i is incremented in the for loop. Since *p points to the top of the ATmega328 SRAM at 0x80ff, then subtracting 1 from it points it to the next lower address 0x80fe; continuing to subtract 1 sequences the address further down until we have 0x80f0. Also note that we passed the pointer by using just the pointer name without the *. These are tricky factoids that you must master to consider yourself proficient in C.

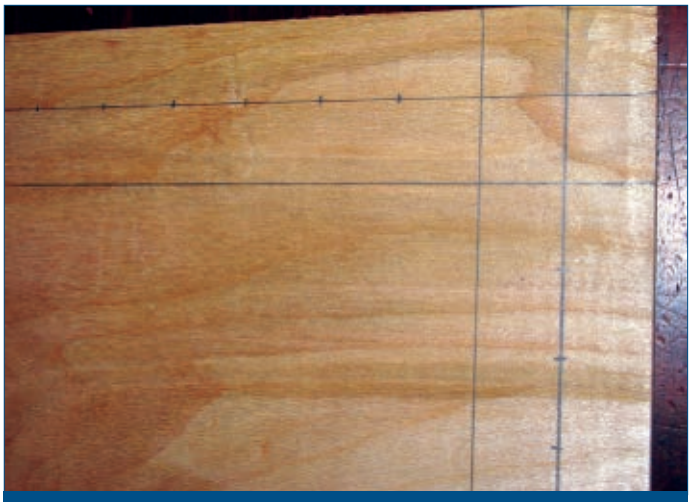
You can find the source code for this in

■ FIGURE 6. Drawing for frame dimensions.

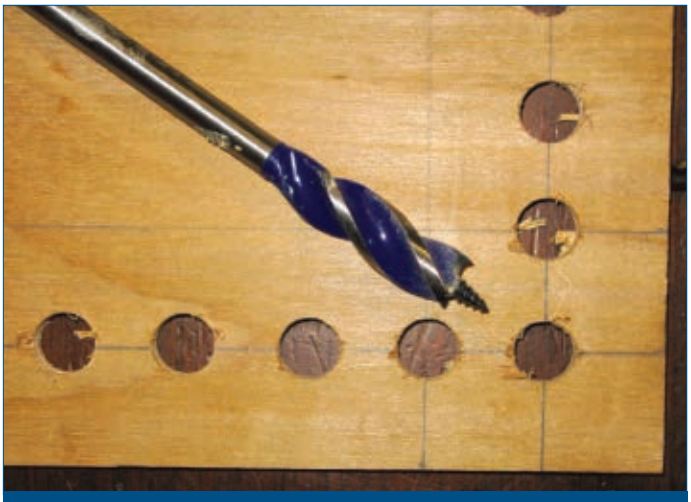


■ FIGURE 7. Drawing for frame on plywood.





■ FIGURE 8. Frame dimensions transferred to plywood.



■ FIGURE 9. LED holes drilled in plywood.

avrtoolbox\avr_applications\pointer_test\. When you compile this code, you will get a warning that variables b and c aren't used. They are included just to pack two spots in memory, as you'll see in a moment. When you run this code, you get the output on Bray's terminal shown in **Figure 5**, which just happens to be the data shown in **Figure 4**. Well, I've explained pointers as best I can, redundantly over-explaining them from several angles. If you haven't got it by this point, try writing your own code and asking questions (careful well-formed questions) on **www.avrfreaks.net**. Someone there might be able to help.

Lab

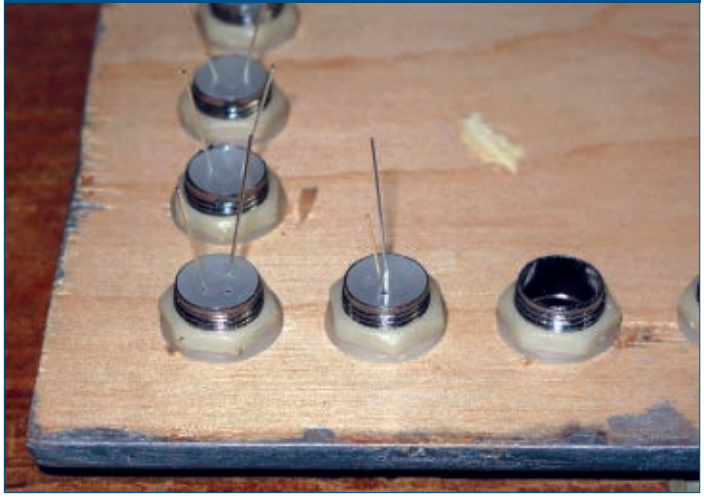
Last month, we started with a picture of a Photoshopped mockup of a movie lobby card chaser light frame and we discussed the theory for using the simple chaser lights kit (available from *Nuts & Volts*) to drive 56 LEDs from eight bits of output. We also saw the schematics and bill of materials. This month, I'll discuss how I built a hardware prototype as shown in **Figure 1**, and demonstrate it in the YouTube video titled 'LED Chaser Light Frame' at **www.youtube.com/watch?v=0wLZwqjYSDk**.

Measure Twice, Cut Once

Or, maybe measure 12 times and cut once? Spacing 56 LEDs around a lobby card is harder than it looks. I had an image of a lobby card for the movie 'Forbidden Planet' and decided that I would array 56 LEDs (which are seven sets of the eight LEDs available for the simple chaser lights output.) Naturally, I wanted to keep this as simple as possible, but I discovered very quickly that spacing those LEDs at some easily measurable intervals around a picture size (that I initially set as 11 x 14 inches which is a standard frame size) was a nightmare of fractional inches that I just didn't have on my ruler. I really wasted a lot of time on this trying to get it to some actual measure that could be expressed on 1/8 inch intervals (or even 1/16), but it never looked right.

■ FIGURE 10. Frame spray painted.

■ FIGURE 11. Mounting bezels and LEDs.



So, finally I settled on making the LED intervals at one inch each and then simply fit the lobby card image using Photoshop to get it close to the inner frame dimensions (I ended up chopping the 11 x 14 to 10 x 14).

Figure 6 shows that I used a T-square and a ruler to draw the inner and outer frame dimensions, along with the LED positions on some newsprint. Even though I was confident in my math, I nonetheless had to re-do this three times to get the final dimensions that I found acceptable. Maybe you'll find this process easier than I did.

By this point, I was so nervous about getting this right that I decided to do my prototype using a piece of inexpensive 1/4 inch plywood (smooth beech on one side), cut to 18 x 14 (**Figure 7**). I then carefully transferred the drawing to the board.

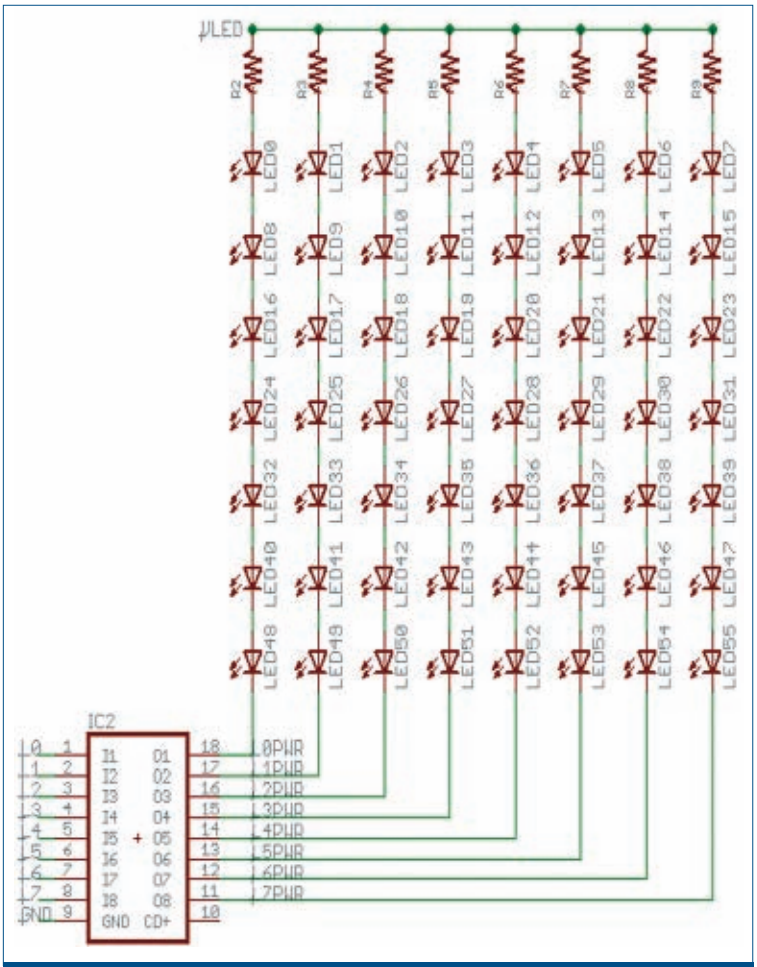
Dimensions

Frame outside: 18 x 14 inches.
Frame LEDs: 16 x 12 inches with LEDs spaced one inch apart.
Frame inside (image size): 10 x 14 inches.

Figure 8 shows the paper dimensions transferred to the plywood. I used a drill press and was very careful to get the drill centered before drilling. **Figure 9** shows the drill — 1/2 drill since the LED bezels are ~1/2 inch. (More on this "~1/2" in a moment). I recommend trying this with a few holes on some scrap board so you can learn how to lessen the ripping up of chunks which seems very easy if you move the drill too fast.

I also bought some hammered metal-silver spray paint so that the prototype would look a little more like the metal frame (**Figure 10**) I envisioned that rather than a ratty piece of plywood. Yes, I'm an optimist.

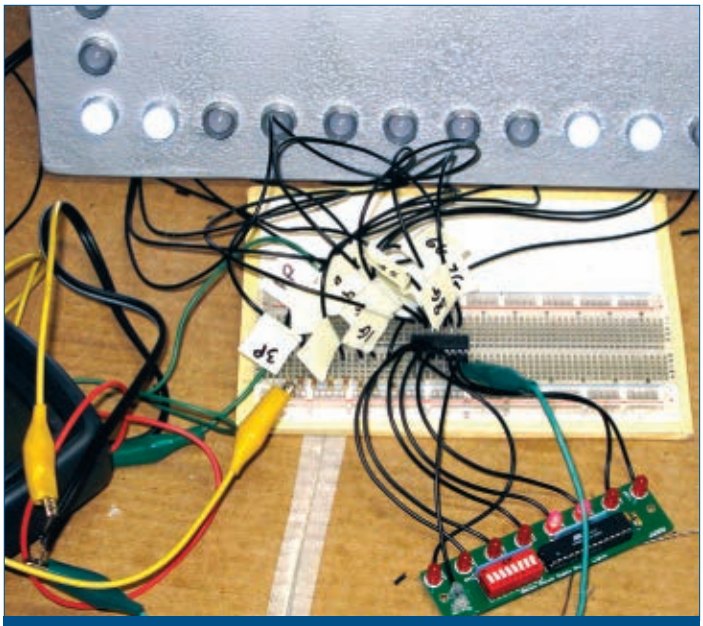
Figure 11 shows the bezels and the LEDs from the back. The "~" 1/2 inch for the bezel drill is from the fact that the bezels were in metric dimensions and I could only find an English drill. The 1/2 inch was close but wasn't quite right, so I compensated by using the ancient technique of shoving them into the hole with pounding, cursing, and sweat. [Of course, it turned out looking



■ FIGURE 12. Schematic for LED matrix and ULN2803 driver.

■ FIGURE 13. Wiring it up.

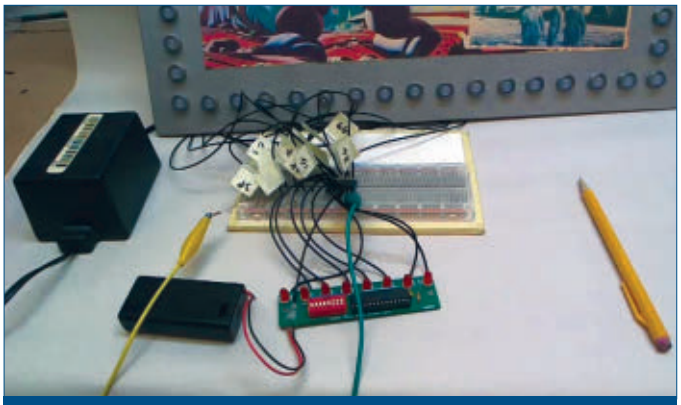
Theory is all well and good, but to really learn this stuff you have to get your hands on some tangible items that blink, whirr, and sometimes detonate. As a service for the readers of the Smiley's Workshop articles, we have simple and inexpensive projects kits available that can help you make it real. You can find these kits (and some darn good books) at the *Nuts & Volts* Webstore.



■ FIGURE 14. Breadboard close-up.

like a ratty piece of plywood painted with hammered metal-silver, but what are prototypes for? It did confirm to me that the dimensions were sound and the LED appearance was more or less what I expected.] Next, I wired it up according to the schematic shown in **Figure 12**.

Last month, I mentioned that I scrounged an old printer power supply that said 30 volts on the case. Since the LEDs dropped 3.4 volts each, I assumed that 3.4*7 = 23.8 volt drop. However, when I started running things, I noticed that the power supply was actually putting out 38 volts, until I hooked it all up and ran it. Then it seemed to be supplying 28 volts. Either way, the LEDs were too bright so I ended up using 2 Kohm resistors which gave an acceptable brightness at



Chaser Demo 1.

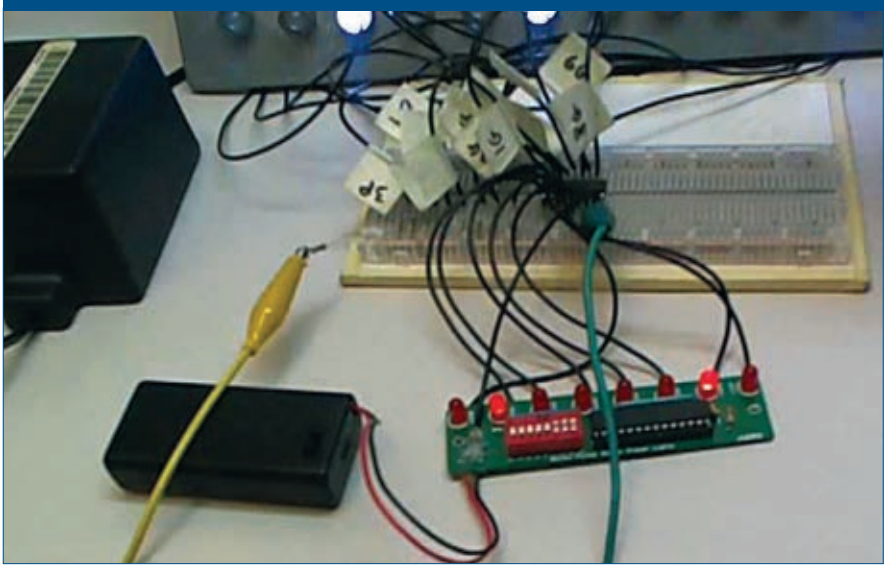
whatever the real current was. Nothing heated up, caught fire, or exploded, so I'm happy.

You may notice that this schematic differs from the one shown last month where I indicated using discrete transistors. That would work, but I just happened to have a ULN2803 lying around and thought it would be easier to wire up on the breadboard as shown in **Figure 14**. [Note also that the L0 to L7 in **Figure 12** refer to the LED0 to LED7 signals shown in Figure 9 from last month's article.]

Figure 13 shows the mess that occurred while building. Note that the deep stains in the cup are from tea — lots and lots and lots of tea — that I drank while building this device. This was due to burning out a string of seven LEDs, then immediately burning out another seven right before a long grumpy walk in which I barked back at several annoying dogs who failed to realize how easy they have it compared to that of the lonely fumble-thumbed prototyper.

Notice in **Figure 14** that I put masking tape flags on each wire marking the LED line number and whether it went to P for power or G for ground.

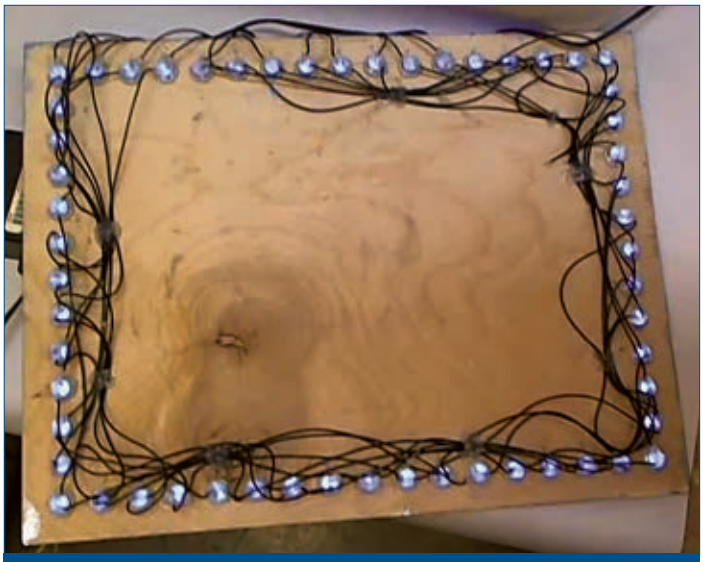
Chaser Demo 3.



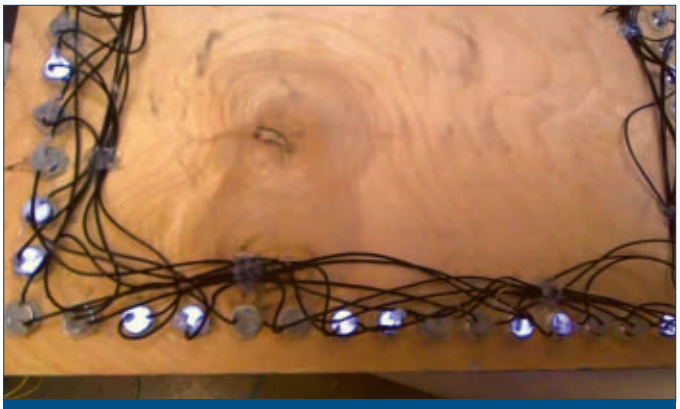
See It in Action

After the hours of building, the burned-out LEDs, and the impolite dogs,

Nuts & Volts now carries the entire line of Smiley Micros books and kits. Some are shown in the magazine and others in their web shop. If you just can't wait and want to get a leg up on real C programming for the AVR (while helping support your favorite magazine and technical writer), then buy my C Programming book and Butterfly projects kit, or if you are a complete novice try *The Arduino Workshop* and projects kit.



Chaser Demo 4.



Chaser Demo 5.

I fired it up and started running the various patterns that come with the Simple_Chaser_Lights kit. To my surprise, many of those patterns are boring on a frame.

The show_all function in the code supplied with the kit is sort of okay, but some of the patterns just don't translate well. So, I decided to write another program that would show a few select patterns in a way that would be a bit more attractive.

Remember, though, that the kit does not have a bootloader or serial communications, so you'll have to have a device that can program an ATmega328 such as the STK-500 or an AVR Dragon. I made a video (titled 'LED Chaser Light Frame') of it running some patterns that you can see on YouTube at **www.youtube.com/watch?v=0wLZwqjYSDk**. I shot the video with the frame on the desk where I made it rather than cleaning it all up and hanging it on the wall like you might expect. I was afraid that if I moved it ... well, who knows what might happen. It's a breadboarded prototype, after all.

Since the source code for the frame is different from that for the simple chaser lights kit, I've bundled it into a zip file (simple_chaser_frame.zip) that you can get from *Nuts & Volts* or from my blog post for this project. See you next time! **NV**

Questions? *Nuts & Volts* is hosting forums for its writers and you can find mine at **http://forum.servomagazine.com/**. If you want a really quick response — especially to a question not directly related to an article — you could put on your biohazard suit and start a thread on **www.avrfreaks.net**. Read my blog entry first that will tell you why you need the biohazard suit at **http://smileymicros.com/blog/2011/01/24/using-an-internet-forum/**.

FUNDAMENTALS

CIRCUITS AND BASICS FOR THE BEGINNER

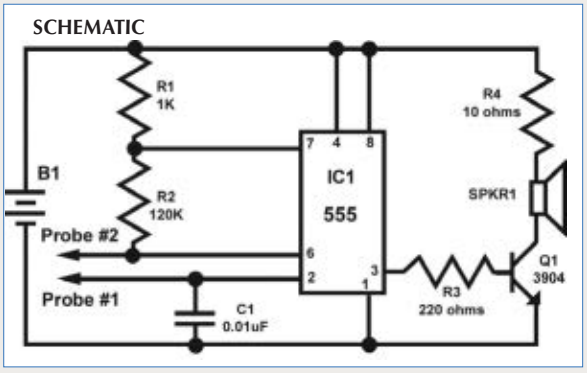
Build a Nose Beeper

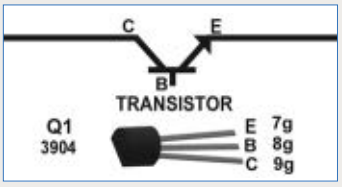
A kit for these experiments can be purchased from the *Nuts & Volts* Webstore at www.nutsvolts.com or call us at 800-783-4624.

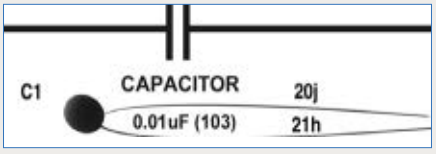
With this circuit, when you touch your friend's nose you can make the speaker sound.

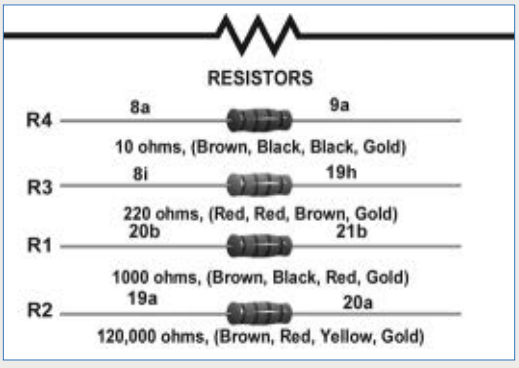
Build the Circuit. Using the schematic along with the pictorial diagram, place the components on a solderless breadboard as shown. Verify that your wiring is correct.

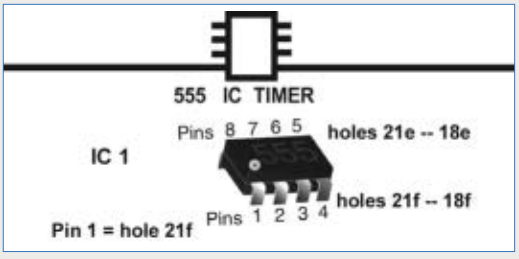
Do the Experiment. Theory: Here, we have a 555 timer IC working as a clock, putting out pulses from pin 3. Transistor Q1 amplifies these pulses and sends them to the speaker. The loudness of the speaker can be increased by mounting the speaker in an enclosure or adding more stages of amplification. **Procedure:** This experiment uses human bodies like wires. Connect a nine volt battery to the battery snap and hold one of the probe wires between your fingers while a friend holds the other. You can make a chain of people as long as you want extending from each wire, and the circuit will work the same. When you reach across and touch the nose of your friend, you complete the circuit so the speaker will beep.

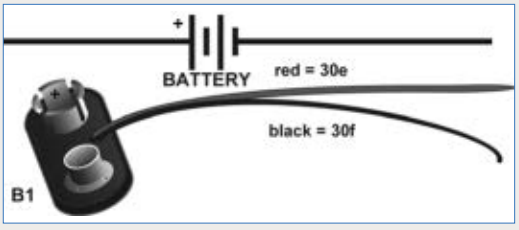






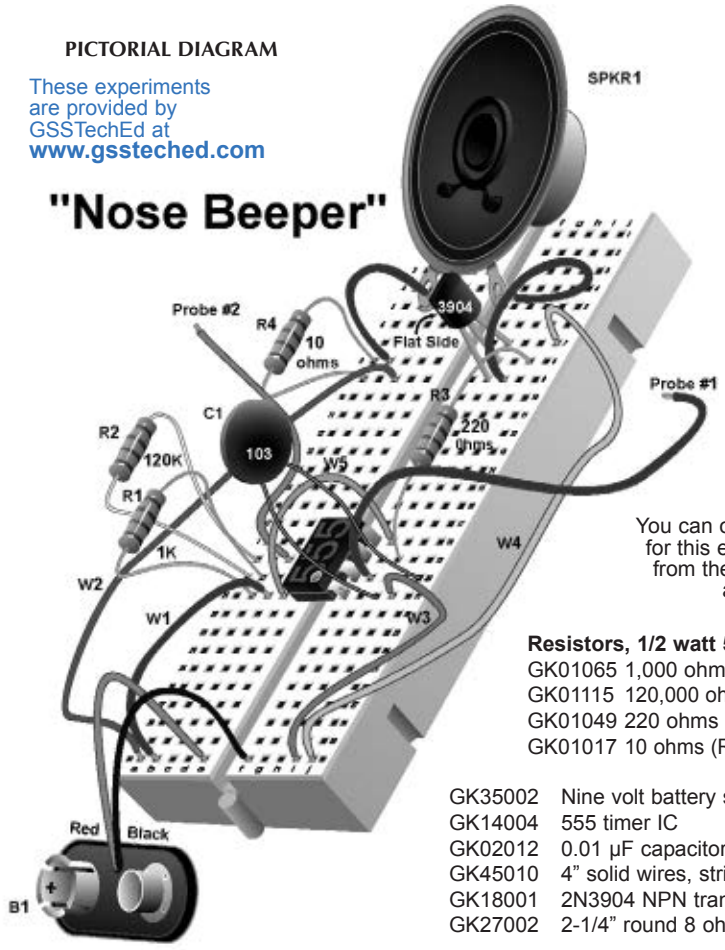






PICTORIAL DIAGRAM

These experiments are provided by GSSTechEd at www.gssteched.com



You can order parts for this experiment from their website as follows:

Resistors, 1/2 watt 5%
GK01065 1,000 ohms (R1)
GK01115 120,000 ohms (R2)
GK01049 220 ohms (R3)
GK01017 10 ohms (R4)

GK35002	Nine volt battery snap
GK14004	555 timer IC
GK02012	0.01 µF capacitor
GK45010	4" solid wires, stripped ends
GK18001	2N3904 NPN transistor
GK27002	2-1/4" round 8 ohm speaker

WIRES
W1 = 21c and 30b
W2 = 9c and 30a
W3 = 21i and 30i
W4 = 7j and 30j
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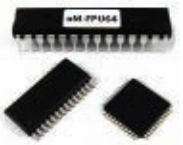

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Continued from page 30

The Parani-MSP1000 is based on an embedded Linux system and it supports strong security mechanisms such as SSL, TLS, SSH, and IP filtering functions. Users also can customize the features of the box easily by using Python script. Typical application areas for the Parani-MSP1000 include:

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For more information, contact:
Lemos International
Web: **www.lemosint.com**

READER-TO-READER TECHFORUM

>>> QUESTIONS

Display Advice

I need to build a high visibility display unit that consists of 15 1″ x 1-1/2″ display units. I've considered LEDs, Electrolum panels, and more. I cannot seem to find a display unit that can properly display true black and true white. I also need them to do at least 256 colors as well — nice, rich high resolution colors.

Is there such a thing? I believe I've seen them but am not sure where since I go to a lot of places displaying a lot of stuff.

#5121 **Tom Moore**
Beverly Hills, FL

LED Chaser

I need a schematic for an LED chaser for an atomic model my class is building. I will be using about eight to 16 LEDs. They need to be adjustable in cycling and speed. Could this circuit be expandable from, say, four to 40 LEDs?

#5122 **Robert Slusher**
Santa Fe, NM

USB Picture Ornament Not Installing

I have a Fourstar Group Vuescape 1.5" Digital Display Ornament, Model 11010025. It's supposed to have a built-in USB driver and application that loads when plugged into a computer's USB port. However, when it's plugged in, the "Device Driver Not Successfully Installed" message displays. When researched, Code 43 is identified. Fourstar Group says the driver and program are internal and unavailable as a separate download.

Since the ornament is not recognized, it does not show up as an external drive to find and launch the application as Fourstar Group suggested. Is there a way to force installation of a similar driver for a similar device, if I can find one *(common type of 1.5" digital display)*? I've tried on different computers and operating systems, so it should be generic.

#5123 **Mark**
San Jose, CA

Bird Sound Circuit

About 40 years ago, I built a bird sound kit and put it in a Sucrets® metal box *(same size as an Altoids® tin)*. I don't remember the name of the company, but the circuit was a blocking oscillator. I believe it had a miniature audio transformer; one side had a center tap. I think it only had one transistor and ran on a single AA cell. I used a 1" speaker with a clear plastic diaphragm. You switched it on and it made a realistic repeating bird chirp. Better yet, if you lightly touched the speakercone, the sounds changed to other types of birds because of the change in reactance of the speaker. It was quite loud. Does anyone remember this and have a schematic?

#5124 **Charles Foreman**
Glendale, CA

Looking For Datasheets

I have a collection of one and two Meg memory strips from early PCs, with which I would like to make delay lines for digitized audio. I can find no application or pin-out data for the chips; the markings seem inconsistent from strip to strip, and have no manufacturer's name or logo. (I have one set of what I believe to be four Meg strips designated as MT4C4ME8DJ.) I've done Google searches for this style of memory chip to no avail. Can anyone help?

#5125 **Arne Berg**
Huntington Beach, CA

>>> ANSWERS

[#3122 - March 2012]
Monitoring Thermostat

A programmable thermostat switches a 24 VDC relay to control 240 VAC electric heaters. I would like to know when and for how long the heaters are on and off in a 24 hour time span, although 12 hours would be okay. Is there such a thing as the electronic equivalent of a chart recorder that can display via Windows XP, and be built for less than a small fortune in time and money?

#1 If you are up to messing with a microcontroller, I have a solution based on using an Arduino and a Flash memory card to save the data. To better flesh out the project, I have created a web page with a description (I did bench test it) and schematics: **https://sites.google.com/site/thermostattracker/home**.

Basically, you use a small front end to transform the thermostat signal for the Arduino microcontroller input, run a program on the Arduino to collect the data, and store it on a Flash memory card that is plugged into a daughter card (referred to as a "shield") on the Arduino. Then, you can take the Flash memory card and plug it into a PC for post-collection data analysis (example, import to a spreadsheet). I'd estimate about $75 for the parts; almost all are available at a RadioShack. I also used the free Arduino simulator available at **arduino.om.au** to aid in the programming.

Pete Lunt
Raleigh, NC

All questions *AND* answers are submitted by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving technical problems. Questions are subject to editing and will be published on a space available basis if deemed suitable by the publisher. Answers are submitted by readers and **NO GUARANTEES WHATSOEVER** are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals.

Always use common sense and good judgment!

Send all questions and answers by email to **forum@nutsvolts.com**
*Check at **www.nutsvolts.com** for tips and info on submitting to the forum.*

#2 If you are interested in knowing how long the heaters were running for the least amount of time and money, I would suggest using a panel mounted hour meter. You can get the meters from Digi-Key, Allied Electronics, or any well stocked supplier. I would suggest getting a meter that responds to the 24 VDC relay coil voltage. The one advantage is that you can get a cumulative reading of the time the relay is energized without having to utilize a computer. While a computer program is nice, if you should take a power bump your computer may shut off and you lose the data you were trying to get. Since the meter is directly powered, if you lose power and then it is restored the meter will keep working.

Craig Kielhofer
Des Moines, IA

[#4121 - March 2012]
Half Cycle Magnetizer

I would like to find a schematic for a half cycle magnetizer. The one that I have runs on three phases but I need one that runs off of the 120 volt line at 60 cycles. The working load that I need is about 5" x 5" x 4" or bigger. The specs for the output coil and the fast solid-state switch are most important. I realize that the magnetizer must be enclosed with non-magnetic material and probably uses a big heatsink.

Check out the Oersted Technology article at **http://oersted.com/magnetizing.PDF**.

Peter A. Goodwin
Rockport, MA

[#4122 - March 2012]
Transformer

How do I calculate the number of turns for both the primary and the secondary windings of a transformer?

#1 The question about transformers does not admit to a simple answer. The primary and secondary windings are applied such that the ratio of the number of primary and secondary turns is identical to the ratio of the primary and secondary voltages. However, the above statement presumes an ideal transformer. It also presumes that the designer has already considered the frequency and waveform of the voltage applied to the primary winding, heating, and safety considerations, etc. This knowledge is required in order to permit the

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designer to select the proper type and physical size of the transformer core material, the bobbin construction, and other matters.

If your interest is constrained to power-frequency transformers — principally 50 Hz in your part of the world — I found an interesting treatise at **http://ludens.cl/Electron/trafos/trafos.html**. His complementary article at **http://ludens.cl/Electron/Magnet.html** discusses the underlying physical properties relative to transformer design.

Peter Goodwin
Rockport, MA

#2 Since you are asking about the primary turns, we assume that you need equation (2) of **Figure 1**, and you are experienced enough to already be familiar with equation (3), listed for reference. We also assume that you are interested in rewinding a power transformer (50/60 Hz) rather than an audio or radio frequency transformer. The main task is to get the minimum required number of primary turns without saturating the core, otherwise smoke. Everything else is just details.

An E-core transformer core is shown in the **figure**. It is constructed from a stack of alternating "E" and "I" shaped laminations of silicon steel. The "not shown" windings go around the center leg through the two windows. The key to the design is the cross-section area of the center leg through which the magnetic lines of flux pass. The Area (A_e) is the width of the center leg (w) times the height (h) of the stack. The A_e determines: 1) the power output capability (Wo); and 2) the number of primary turns (Np). It should be no surprise that a bigger core (A_e) supports more power (Wo). Bigger cores require fewer turns of larger wire than smaller cores.

Start out with either equation 1a or 1b. If you are starting with a known power output requirement (Wo), use 1a to determine the required center leg core area (A_e). Example: A 100 watt (Wo) transformer operated at 60 Hz requires A_e = sqrt(100)/5.58) *sqrt(60/60) = 1.77 sq in center leg core. You then need to select a stack of laminations for which w and h multiply out to 1.79 sq in, or more.

More likely, you have a discarded transformer on hand that you want to rewind with custom windings. Equation (1b) tells us how much power (Wo) a center leg of a given area will support. Knowing the wattage allows us to select the proper wire sizes for both windings. Example: We have a 1.0 in stack of 1.0 in wide laminations = A_e = 1 sq in: Wo = (60/60)*(squared5.58 * 1.0) = (31 watts).

The minimum number of turns for the primary is given by equation 2 in terms of the primary voltage (Vp), frequency (f), center leg E-core area (A_e), and flux density of 80,000 lines per square inch. Example: Our 31 watt 1.0 square inch core is to be operated at 120 VAC, 60 Hz; Np = (120 * 10e8)/(4.44 * 60 * 1.0 * 80,000) = 563 turns.

If our 31W, 120V, 563 turn primary were to be accompanied by a 12V secondary, the voltage ratio is 1/10. The secondary turns Ns is proportional (equation 3). Ns = 56.3 turns. This is the open circuit voltage. Optionally, if we want the loaded voltage to be closer to 12V, add 5% more turns to the secondary (not shown in equation 3). Ns' = 1.05*Ns = 1.05*56.3 = 59 turns.

What size of wire should be used for our example 31W 120V : 12V transformer? Answer: Choose a wire gauge having approximately 1,000 circular mils of cross-section per ampere of current. See **Reference [2]** for a wire table. The 120V, 31W primary has I = P/V = 31/120 = 0.26 A current. Closest is AWG #26 wire with 254 cir mils cross-section for the primary. The secondary current is I = P/V = 31/12 = 2.58 A. Closest is AWG #16 with 2583 cir mils.

Note: The above formulas based on **Reference [1]** predict a full load temperature rise of 50 degrees C. If this is too hot for your application, decrease the flux density of 80,000 lines per square inch by 20%.

Practical considerations: In the olden days, it was possible to disassemble a transformer by removing the bolts compressing the lamination stack, then knocking out the laminations with a hammer and screwdriver. These days, disassembly may be impossible due to epoxy applied to the laminations. If possible, recover the insulating form on which the coil is wound from your scrapped transformer. This is a hard-to-make item. If you are modifying a not-burned-out transformer, only remove the secondary; re-using the primary.

Some small transformers — like the open frame RadioShack products — may have a large enough window space remaining to add windings atop the existing secondary. If you only need a few volts, or want to add a few volts to the existing secondary, the

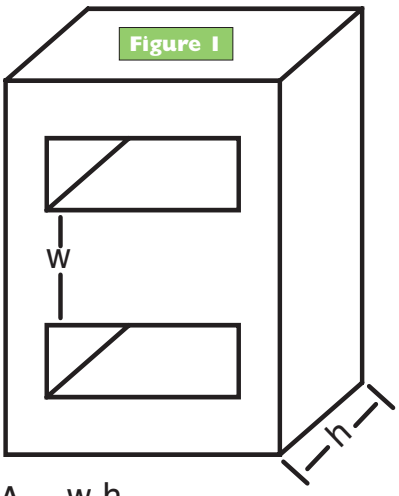

Figure 1

$$A_e = w \cdot h$$

$$A_e = \frac{\sqrt{Wo}}{5.58}\sqrt{\frac{60}{f}} \quad (1a)$$

$$Wo = \frac{f}{60}(5.58 \cdot A_e)^2 \quad (1b)$$

$$Np = \frac{Vp \cdot 10^8}{4.44 \cdot f \cdot A_e \cdot B} \quad (2)$$

$$Ns = Np\ (Vs/Vp) \quad (3)$$

where:
Wo = output wattage
B = 80,000 lines/in.
f = line frequency
A_e= core leg area (in^2.)
Np = no. of turns primary

turns may be threaded through the windows without disassembly. Temporarily, tape sharp window edges to prevent scraping the wire while threading.

References:

[1] *Reference Data for Radio Engineers*, 4th ed, "Design of Power Transformers for Rectifiers," pp 25, 1964, ITT.

[2] *Lessons In Electric Circuits*, Vol 5, Ch 3, Copper wire gauge table, **www.ibiblio.org/kuphaldt/electricCircuits/Ref/REF_3.html**.

Dennis Crunkilton
Abilene, TX

#3 Here are three video tutorials on building a transformer from an old microwave. They go into the design and windings design pretty well *(alternative: just go to youtube.com and search on "mot salvage tutorial"):*

www.youtube.com/watch?feature=player_embedded&v=KRoPHKpCYmg

www.youtube.com/watch?feature=player_embedded&v=YX3mYO-BIuQ

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Pete Lunt
Raleigh, NC

[#4123 - March 2012]
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I am an electrical technician looking for a textbook or reference that deals with landline phones. I am wanting to learn the info that a phone technician would use such as multi-phone land lines, troubleshooting phone lines, and the definitions that are used in the industry.

Please direct me to a text book that would be a useful resource of learning and a good reference for down the road.

For a book on telephone electronics, see:

ISBN-10: 0750699442

ISBN-13: 978-0750699440

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Raleigh, NC

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Jaycar Electronics....39
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Ramsey Electronics, Inc. 22-23

CIRCUIT BOARDS
AP Circuits 79
Cunard Associates 30
Dimension Engineering....8
ExpressPCB 37
Front Panel Express LLC 38
PCB Pool 28
R.E. Smith Inc. 38
Saelig Company Inc. 62
V-Module 61

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Cana Kit Corp. 75
Chaney Electronics 13
Electronix Express 29
Fun Gizmos 30
Jameco 4
NightFire Electronics....8
Noritake 20
V-Module 61

COMPUTER
Hardware
Earth Computer Technologies 79
Noritake 20
Weirdstuff Warehouse 30

Microcontrollers / I/O Boards
Abacom Technologies 21
Bitscope 9
Fun Gizmos 30
microEngineering Labs....29
MikroElektronika 3
Parallax, Inc. ....Back Cover
Pololu Robotics & Electronics....5

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Cana Kit Corp. 75
ExpressPCB 37
Front Panel Express LLC 38
PCB Pool 28
RockAuto LLC....38

DIGITAL OSCILLOSCOPES
Rigol Technologies....30

EDUCATION
Bitscope 9
Command Productions 21
Global Specialties 7
GSS Tech Ed 62
NKC Electronics 30
Poscope....57

EMBEDDED TOOLS
NetBurner 2

ENCLOSURES
Front Panel Express LLC 38

EVENTS
AUVSI 45
Maker Faire....63

KITS & PLANS
Cana Kit Corp. 75
Chaney Electronics 13
Earth Computer Technologies 79
GSS Tech Ed 62
Jaycar Electronics....39
NetBurner 2
NightFire Electronics....8
NKC Electronics 30
QKITS....30
Ramsey Electronics, Inc. 22-23

MISC./SURPLUS
All Electronics Corp. 31
Chaney Electronics 13
Front Panel Express LLC 38
Weirdstuff Warehouse 30

MOTORS
Jameco 4

OPTICS
Noritake 20

PROTOTYPING & TRAINERS
Global Specialties 7

PUBLICATIONS
Lakeview Research 30

PROGRAMMERS
microEngineering Labs....29
MikroElektronika 3

RF TRANSMITTERS/RECEIVERS
Abacom Technologies 21

ROBOTICS
Fun Gizmos 30
GSS Tech Ed 62
Jameco 4
Lemos International Co., Inc. 30
Lynxmotion, Inc. 51
Pololu Robotics & Electronics....5
Robot Power 30

SATELLITE
Lemos International Co., Inc. 30

TEST EQUIPMENT
Bitscope 9
Circuit Specialists, Inc. 82-83
Dimension Engineering....8
Global Specialties 7
HAPRO Electronics 61
Jaycar Electronics....39
NKC Electronics 30
Poscope....57
Rigol Technologies....30
Saelig Company Inc. 62

TOOLS
MikroElektronika 3
NetBurner 2
PanaVise 28
Poscope....57

WAVEFORM GENERATORS
Rigol Technologies....30

Abacom Technologies 21
All Electronics Corp. 31
AP Circuits 79
AUVSI 45
Bitscope 9
Cana Kit Corp. 75
Chaney Electronics 13
Circuit Specialists, Inc. 82-83
Command Productions 21
Cunard Associates 30
Dimension Engineering....8
Earth Computer Technologies 79
Electronix Express 29
ExpressPCB 37
Front Panel Express LLC 38
Fun Gizmos 30
Global Specialties 7
GSS Tech Ed 62
HAPRO Electronics 61
Jameco 4
Jaycar Electronics....39
Lakeview Research 30
Lemos International Co., Inc. 30
Lynxmotion, Inc. 51
Maker Faire....63
microEngineering Labs....29
MikroElektronika 3
NetBurner 2
NightFire Electronics....8
NKC Electronics 30
Noritake 20
PanaVise 28
Parallax, Inc. ....Back Cover
PCB Pool 28
Pololu Robotics & Electronics....5
Poscope....57
QKITS....30
Ramsey Electronics, Inc. 22-23
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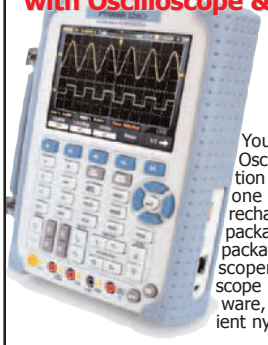

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